PART V.

MOSASAURS.

By S. W. WILLISTON.

Plates X–LXXII.

MOSASAURS.

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HISTORICAL.

It is now more than a century since the first specimen of the singular group of reptiles known as the Mosasaurs was discovered, and only at the present time has our knowledge of them become at all complete. No group of extinct reptiles has been more abundantly represented as fossils, unless it be the Dinosaurs, and in no group have more skeletons and parts of skeletons been brought to light in the museums. Kansas, *par excellence*, has been the great collecting ground of the world for these reptiles. Since first a specimen was discovered by Doctor Turner, of Fort Wallace, in 1868, and taken east by Leconte, to be shortly afterwards described by Cope, many hundreds, yes thousands, of these animals have been collected. Doctors Janeway and Sternberg, at Hays and Wallace, Professors Marsh and Cope, in field expeditions, Professors Mudge and Snow, H. A. Brous, George Cooper, Charles Sternberg, E. P. West, E. W. Guild, H. T. Martin, Professor Baur, E. C. Case and the writer have at different times collected for institutions of America and Europe. A thousand or more specimens are now in the Yale museum, collected at an expense of many thousand dollars, several hundred are in the University of Kansas, and other institutions of America, and others in lesser number are in the museums of Munich and of Great Britain. Scattered publications, based often upon fragmentary material, make it difficult to obtain any connected knowledge of what the forms are in Kansas.

The present work is an endeavor to bring together clearly and distinctly all the important facts about the Mosasaurs of Kansas. The work has been the result of much careful study

of the rich material now in the University of Kansas — material that is sufficient to elucidate nearly all that is to be learned about the Kansas genera and species. Little or nothing has been taken at second hand from other writers, so far as the Kansas Mosasaurs are concerned, and for nearly every statement herein contained the present writer is alone responsible. The general reader who does not care to go through the necessary mass of descriptive matter is referred to the concluding chapter, on the "Restorations of the Kansas Mosasaurs."

The first specimen of Mosasaurs of which we have historical knowledge was discovered by Doctor Hoffman, a surgeon of Maestricht, in 1780, and has been the subject of numerous descriptions and discussions by some of the most famous naturalists of the world. Its discovery, and the subsequent destination of the fossil, is the subject of the following account by M. Faujas-Saint-Fond, in his "Natural History of St. Peter's Mount":

"In one of the galleries or subterraneous quarries of St. Peter's Mount, at Maestricht, at the distance of about 500 paces from the principal entrance, and at ninety feet below the surface, the quarrymen exposed part of the skull of a large animal imbedded in the stone. They stopped their labors to give notice to Doctor Hoffman, a surgeon at Maestricht, who had for some years been collecting fossils from the quarries, and who had liberally remunerated the laborers for them. Doctor Hoffman, observing the specimen to be the most important that had yet been discovered, took every precaution to secure it entire. After having succeeded in removing a large block of stone containing it, and reducing the mass to a proper condition, it was transported to his home in triumph. But this great prize in natural history, which had given Doctor Hoffman so much pleasure, now became the source of chagrin. A canon of Maestricht, who owned the ground beneath which was the quarry whence the skull was obtained, when the fame of the specimen reached him, laid claim to it under certain feudal rights and applied to law for its recovery. Doctor Hoffman resisted, and the matter becoming serious, the chapter of canons came to the support of

their reverend brother, and Doctor Hoffman not only lost the specimen but was obliged to pay the costs of the lawsuit. The canon, leaving all feelings of remorse to the judges for their iniquitous decision, became the happy and contented possessor of this unique example of its kind.

"But justice, though slow, arrives at last. The specimen was destined again to change its place and possessor. In 1795 the troops of the French republic, having repulsed the Austrians, laid siege to Maestricht and bombarded Fort St. Peter. The country house of the canon, in which the skull was kept, was near the fort, and the general, being informed of the circumstance, gave orders that the artillerists should avoid that house. The canon, suspecting the object of this attention, had the skull removed and concealed in a place of safety in the city. After the French took possession of the latter, Freicine, the representative of the people, promised a reward of 600 bottles of wine for its discovery. The promise had its effect, for the next day a dozen grenadiers brought the specimen in triumph to the house of the representative, and it was subsequently conveyed to the museum of Paris."

It is said that after peace was established the canon was reimbursed for the specimen. But it still remains in Paris.

This specimen was described and figured by Cuvier in 1808, and the generic name, *Mosasaurus*, was given to it by Conybeare in 1822; the name being derived from the river Meuse (Latin, *Mosa*), near which it was found, and *saurus*, a reptile.

In 1843 a specimen previously discovered by Major O'Fallon, an Indian agent, at the Great Bend of the Missouri, who had it taken to his home in St. Louis and placed in his garden, was most carefully and fully described by Dr. August Goldfuss,[34] and admirably figured. This description and its accompanying plates were most strangely overlooked or neglected by later authors. The parietal and jugal arches, the pterygoids and vomers, the position of the quadrate and the presence of sclerotic plates, all were clearly described or figured. Nevertheless, they

34. Der Schaedelbau des Mosasaurus, Act. Acad. Caes. Leop. Carol. Nat. Cur., XXI, 1843.

were all later announced as new discoveries. With the exception of some brief and unimportant papers on the group by Morton and Leidy, the next most important contributions to the knowledge of the Mosasaurs are due to the late Professor Cope. Aside from a number of short papers, his chief contributions will be found in his "Synopsis of the Extinct Batrachia, etc.," published in 1870, and his volume on the "Cretaceous Vertebrata of the West," published in 1875. In this last work he enumerates more than fifty species of the group from America. Meanwhile Professor Marsh had described a number of forms and published a number of discoveries concerning the anatomy of these animals, many of which, however, were rediscoveries of Goldfuss. These papers by Marsh will be found in the American Journal of Science. To him is due the discovery of the stapes, columella, transverse and hyoid, and the presence of the hind limbs, which had already been indicated by Goldfuss. Since 1882, Dollo has very materially increased our knowledge of this group, and has established the following new genera in numerous papers: *Plioplatecarpus*, *Hainosaurus*, *Prognathosaurus*, and *Phosphorosaurus*. In 1892 Baur published a complete and minute description of the skull of *Platecarpus*, illustrated by detailed drawings of the different parts, and Williston and Case gave for the first time a description of the vertebral column and more precise knowledge of the extremities and the general form of the Mosasaurs. Later papers by Williston have added to the knowledge of the Kansas forms, and the first correct restoration of any member of this group was given by him. In 1894 was published a valuable illustrated paper on the Kansas Mosasaurs, by Merriam, in which several supposed new forms were briefly described and a number of new details given of the different genera, with more complete generic differences than had hitherto been published. Other papers by Gervais, Gaudry and Owen complete the list of the more important ones on this group of reptiles.

RANGE AND DISTRIBUTION.

The Mosasaurs are at present known from four remote regions of the word—North and South America, Europe, and New Zealand. Doubtless they lived over the greater part of the earth, and may be expected wherever marine Upper Cretaceous deposits occur. Their geological range is confined exclusively to the Upper Cretaceous, from the time corresponding to the upper part of the Dakota to that of the lower part of the Laramie, or from the Upper Cenomanian to the Lower Danian. The correlation of the American Cretaceous deposits with those of Europe, or even with each other, is by no means exact, or even approximately exact. Nevertheless the equivalency of the different strata and epochs is sufficiently well determined to admit of approximate results.

The oldest Mosasaurs are apparently those described by Hector from New Zealand, which he referred to the genera *Liodon* and *Taniwhasaurus* Hector.[35] The genus *Liodon* Owen, Dollo has recently shown to be a synonym of *Mosasaurus*.[36] Whether or not Hector's species is congeneric with those placed under *Liodon* by Cope is not certain, though it is evident that it is closely allied. *Taniwhasaurus* is clearly of the *Platecarpus* type, and may possibly belong to that genus.

The most recent form is the historical *Mosasaurus giganteus* Soemmering (*M. camperi*, *M. hoffmani*), from the Maestricht beds in the Lower Danian. These three forms, *Tylosaurus*, *Platecarpus*, and *Mosasaurus*, represent three distinct and divergent types, which I have called the Tylosaurinæ, Platecarpinæ, and Mosasaurinæ, corresponding to the megarhynchous, microrhynchous and mesorhynchous types of Dollo.[37]

The Tylosaurinæ begin with *Liodon* (*Tylosaurus?*) *haumuriensis* Hector in the Cenomanian of New Zealand, and continue to the Upper Senonian of Belgium as found in the genus *Hainosaurus* Dollo, from the brown phosphatic chalk of Mesvin

35. On the Fossil Reptilia of New Zealand, Trans. and Proc. New Zealand Institute, VI, 338, 1873.

36. Bulletin Soc. Belg. Geol., VII, 79, 1892.

37. Mem. Soc. Belg. de Geol., IV, 163, 1890.

Cipley. In the interior of North America the type, so far as known, begins near the lower part of the Niobrara and terminates at its close or in the beginning of the Fort Pierre; that is, to use the European time periods, with the close of the Turonian or the beginning of the Senonian. Forms ascribed to this genus, the *Liodon* of Cope, are from the Lower Greensand or Lower Marl of New Jersey, but their positive identification is yet uncertain, if not doubtful, since the only characteristic parts, the rostrum, quadrate, and limb bones, have never yet been found. There is nothing improbable in its occurrence in these beds, but hitherto nothing decisively characteristic of *Tylosaurus* has been found there. The genus *Hainosaurus* is clearly of the *Tylosaurus* type. In fact, the two genera are so nearly related that decisive distinctional characters are not yet forthcoming, unless they be found in the paddles.

The Platecarpinæ have a very similar distribution. Beginning in the Cenomanian of New Zealand, in *Taniwhasaurus*, if the deposits of New Zealand are really contemporaneous with this epoch in Europe, they terminate in the closely allied *Plioplatecarpus* Dollo from the Lower Maestrichtian of Belgium. In North America the species upon which the genus *Platecarpus* has been chiefly based are known nowhere outside of Kansas and Colorado, and are here restricted exclusively to the Niobrara. The type species of this genus, *P. tympaniticus* Cope, is from Mississippi, and is in all probability congeneric with the Kansas species, but this has not yet been satisfactorily proven, though it certainly belongs in the Platecarpinæ.

From the Fort Pierre only one species can be referred to this group, and this with doubt. *Brachysaurus* described by myself may belong here, but I believe that its affinities are more close with the Mosasaurinæ. It is certainly closely related to *Prognathosaurus* Dollo,[38] from the Upper Senonian of Belgium, and I should have had little hesitancy in identifying it with that genus had not Dollo stated that the chevrons are free in *Prognathosaurus*.[39]

38. Mem. Soc. Belg. de Geol., III, 193, 1889.
39. Mem. Soc. Belg. de Geol., IV, 163, 1890.

Of the Mosasaurinæ, including the two genera *Mosasaurus* and *Clidastes*, the lowest horizon is the upper part of the Niobrara in Kansas. *Clidastes* ranges into the Fort Pierre, as previously stated by myself. In the eastern Atlantic region this genus is represented by forms closely allied to those from Kansas. Its range, then, is from the upper part of the Turonian through the larger part of the Senonian.

The typical *Mosasaurus* is confined exclusively to the Senonian and Danian. Its distribution in North America is reputed to be from New Jersey, Alabama, and Dakota, but some of the determinations may be incorrect. The species from the Fort Pierre are, however, clearly congeneric with one or more from New Jersey. In Europe, *Mosasaurus* is known only from the Upper Senonian and the Danian (upper chalk and Maestrichtian) ; that is, apparently, from later horizons than those in which the genus occurs in America.

The two genera *Mosasaurus* and *Clidastes* are nearly related, though perhaps sufficiently different to justify their independent existence.

From the known distribution of the Mosasaurs, Dollo has concluded :

"Que la Nouvelle-Zéland (ou, mieux, les terres australes) est le centre d'irradiation des Mosasauriens, qui en seraient partis à la fin de l'époque cénomanienne, auraient vécu uniquement en Amérique durant l'époque turonienne, auraient émigré en Europe à l'époque sénonienne et s'y seraient éteints avec l'époque maestrichtienne."

The fact that Mosasaurs have been reported from the Amazonian Purus, corresponding to the Maestrichtian, would certainly indicate that they had not become at all restricted in distribution in the latter part of their existence.

The distribution of the Mosasaurs, so far as now known, seems to be of little value in the correlation of the Cretaceous epochs. Only a single genus seems to be of wide distribution, and the nearly related ones may be widely separated in geological range. Two, perhaps three, distinct types appear suddenly in the Cenomanian, and have continued side by side in the same waters throughout the greater part of the time during which

the group has been in existence. Some minor divergent forms have appeared, such as the singular *Phosphorosaurus* Dollo, *Prognathosaurus*, and *Brachysaurus*, and, perhaps, *Baptosaurus* Marsh, which, by the way, is one of the latest American forms, from the Upper Greensand or Marl of New Jersey, and occurring, also, if Merriam's determination is correct, in the Niobrara of Kansas.

The common aquatic ancestor of the three types must be sought for in a much earlier period, certainly in the Lower Cretaceous. The rudimentary or possibly functional zygosphene among the Platecarpinæ, or some members of it, and the complete zygosphene in *Clidastes*, together with the shortened muzzle and more fully ossified paddles, indicate a much closer relationship between the Platecarpinæ and Mosasaurinæ than between either and the Tylosaurinæ. In the last we find, in some forms at least, that the fifth finger is actually longer than the fourth, with as many phalanges, and that the carpus and tarsus are almost wholly unossified. If we assume with Dollo that the zygosphene is a primitive character, (and it must be unless it had an independent origin among the Mosasaurs,) then *Clidastes* would be the most generalized and *Tylosaurus* the most specialized of the Mosasaurs. In the paddles and skull, *Tylosaurus* is, with hardly a doubt, more specialized than any other genus. However, although *Clidastes* may retain some of its primitive characters, it certainly shows in many other respects a high degree of specialization.

I give below a tabular review of the known genera of the Mosasaurinæ arranged in systematic sequence, using the European time epochs for comparison's sake. Of course it is understood that the exact equivalency of these time periods is yet a matter of uncertainty.

TYLOSAURINÆ.

Tylosaurus Marsh.

Cenomanian of New Zealand (*Liodon haumuriensis* Hector).
Upper Turonian of Kansas and New Mexico (Niobrara).
? Senonian of New Jersey (Greensand).

Hainosaurus Dollo.

Upper Senonian of Belgium (brown phosphatic chalk of Cipley).

PLATECARPINÆ.

Platecarpus Cope.

Upper Turonian of Kansas and Colorado (Niobrara).

? Senonian of Mississippi.

Plioplatecarpus Dollo.

Lower Maestrichtian of Belgium (Danian).

Prognathosaurus Dollo.

Upper Senonian of Belgium (brown phosphate of Cipley).

? Brachysaurus Williston.

Senonian of Dakota (Fort Pierre).

Sironectes Cope, and ***Holosaurus*** Marsh.

Upper Turonian of Kansas (Niobrara).

Taniwhasaurus Hector.

Upper Cenomanian of New Zealand.

MOSASAURINÆ.

Mosasaurus Conybeare.

Lower Danian of Belgium and England (Upper and Lower Maestrichtian and Upper Chalk).

Upper Senonian of Belgium (brown phosphate of Cipley).

Senonian of New Jersey and Dakota (Greensand and Fort Pierre).

? Senonian of Alabama and North Carolina.

Clidastes Cope.

Uppermost Turonian or lowermost Senonian of Kansas and Colorado (Niobrara and Fort Pierre).

Senonian of New Jersey, Alabama, and Mississippi.

INCERTÆ SEDIS.

Baptosaurus Marsh.

Upper Senonian of New Jersey (Upper Greensand).

Upper Turonian of Kansas (Niobrara).

Phosphorosaurus Dollo.

Upper Senonian of Belgium (brown phosphatic chalk of Cipley).

CRETACEOUS EPOCHS OF THE UNITED STATES AND EUROPE.

		Atlantic border.	Gulf border.	Southern interior.	Northern interior.	Pacific border.	France.	England.
Upper Cretaceous.	1	Wanting.	Wanting.	Wanting.	Denver.		Danian.	
	2	Upper Greensand.	Wanting.	Laramie.	Laramie.			
	3	Middle and Lower Greensand.	Ripley. Upper Rotten Limestone.	Glauconitic. Ponderosa Marls.	Montana. Fox Hills. Fort Pierre.		Senonian.	Upper, Middle and Lower Chalk.
	4	? Clay Marls.	Lower Rotten Limestone.	Austin Limestone. Eagle Ford Shales.	Colorado. Niobrara. Benton.	Chico.	Turonian.	
	5	Raritan.	Upper Eutaw. Tombigbee.	Lower Cross-timber Sands.	Dakota.		Cenomanian.	Upper Greensand.
Lower Cretaceous.	1	Potomac.	Tuscaloosa.	Comanche.	Kootanie.	Shasta.	Albian. Aptian. Neocomian.	Gault. Lower Greensand. Wealden.

SYSTEMATIC POSITION.

There has been much controversy regarding the systematic position of the Mosasaurs. By many they are considered to be a suborder of the Squamata, coequal with the Lacertilia and Ophidia, and this view has the support of Cope, Boulenger, and Dollo, all eminent herpetologists. On the other hand, Owen, Marsh and Baur contend that they belong among the Lacertilia. If one accepts the division of the Lacertilia into Lacertilia, Rhiptoglossa, and Dolichosauria, then I believe that the suborder Mosasauria should find an independent place with them. But otherwise I believe that they should be included among the Lacertilia in the wider sense as a distinct tribe. Surely the natatory character of their limbs, and the absence of sacrum, together with important differences in the skull, are sufficient to entitle them to a position of their own, distinguished from all other lizards. But, in any event they do not present any distinct relationships with the Ophidia, and the name Pythonomorpha in consequence must be given up.

The history of the controversy between Professor Cope and the various authors who have contended for the subordinate position of the group is of sufficient importance to warrant a brief review here, with references to the literature concerned, to which the reader may turn, should he desire to pursue the subject further.

Cuvier, who was the first to publish a scientific discussion of the nature and structure of the Mosasaurs, contended that they were nearest allied to the Monitors and Iguanas.[40]

Goldfuss, who published an excellent and extended paper on an American form of the group,[41] expressed his views of their relationship as follows: "The depressed, elongate form of the anterior part of the head, the narrow, long nares, the structure of the lower jaw and the presence of the palatal teeth, affirm Cuvier's claim that this genus of animals finds its systematic position between the Monitors and Iguanas. If we follow the

40. Sur le Grand animal fossile des cariere de Maestricht, Ann. Mus. Hist. Nat., XII, 145, 1808.
41. Der Schaedelbau des Mosasaurus, Act. Acad. Caes. Leop. Carol. Nat. Cur., XXI, 1843.

structure of the skull in its details, we are surprised to find here a middle ground in which not only the peculiarities of the above named genera, but indeed also those of most other saurians are united, together with others which are peculiar to them and distinguish them from all others'' (p. 179). ''From the foregoing it is seen that the genus *Mosasaurus* has only the teeth alveolæ in common with the crocodilians and the bony sclerotic ring with the fish-like saurians, but on the other hand is related to the living lizards, and especially agrees with the Monitor'' (p. 188).

In 1869[42] Professor Cope proposed for the reception of the Mosasaurs the erection of a special order, which he called Pythonomorpha, and for which he gave the following characters:

''1. The teeth have no fangs. 2. There is merely a squamosal suture between the maxillary and premaxillary. 3. The opisthotic bone projects free from the cranium, and is the suspensorium of the os quadratum. 4. There is no columella. 5. There is no symphysis mandibuli. 6. The parietal is decurved posteriorly and unites with the alisphenoid, forming the cranial wall in front of the prootic. 7. The subarticular and splenial elements of the mandible are connected by articular faces. 8. The vertebræ are very numerous, much exceeding 100, and frequently present the zygosphene articulation. 9. The abdominal cavity is long and surrounded by many short curved ribs, which have simple heads and a free antero-posterior movement on vertical articulating surfaces, and which commence close behind the axis vertebræ. 10. The pterygoids are elongate and bear numerous teeth, and in one type are free, except at the extremities. 11. The brain-case is not fully ossified anteriorly. 12. Scapula and coracoid elements are present. 13. The caudal vertebræ are furnished with chevron bones. 14. The squamosal bone is present. 15. The angular bone is distinct. 16. The os quadratum is movably articulated to the opisthotic. 17. The os quadratum embraces and incloses the meatus auditorius externus. 18. The opisthotic is supported by a pedestal projecting from the cranial walls, composed of the

42. Proceedings Bost. Soc. Nat. Hist., XII, 253.

prolonged prootic in front and the exoccipital behind, which embraces the suspensorium for much of its length. 19. The anterior limbs are fins, with all the elements in a single plane; the radius incapable of rotation; the humerus broad and flat. 20. There are probably no hind limbs. Of the above characters, the first eight are those of serpents; the five characters following the ninth are lacertian; while the seventeenth is peculiar, and not found in any existing order of reptiles. The eighteenth is characteristic of the Sauropterygia."

In 1875[43] he defined the order Pythonomorpha as follows:

"1. The quadrate bone is attached to the cranium by a ginglymoid articulation, admitting of free movement. 2. The ribs are attached by simple articulations to single articular facets, or diapophyses, springing from the bodies of the vertebræ. 3. There are two pairs of limbs, which form paddles, having the elements arranged in one plane, and incapable of rotation or flexure on each other. 4. There is no sternum. 5. The scapular arch consists of scapula and coracoid only. 6. There is no sacrum. 7. The pelvis consists of slender elements, of which the inferior are nearly transverse, and meet, without uniting, on the middle line below. 8. The opisthotic bone projects free from the cranium as the suspensorium of the quadrate bone, and is supported and embraced by a pedestal projecting from the cranial walls, composed of the prootic in front and the exoccipital behind. 9. The stapes lies in a groove on the posterior side of this suspensorium, and is produced to the os quadratum. 10. There is no quadratojugal arch. 11. The parietal is decurved posteriorly, forming the cranial wall in front of the prootic. 12. The brain chamber is not ossified in front. 13. The squamosal bone is present, merely forming the posterior part of the zygomatic arch. 14. The mandible is composed of all the elements characteristic of reptiles: the articular and surangular distinct; the angular represented by its anterior portion only; and the coronoid present. 15. The atlas consists of a basal and two lateral pieces only; the odontoid is distinct, and is bounded by a free hypapophysis, besides the hypa-

43. Cretaceous Vertebrata, p. 112.

pophysis of the axis. 16. The caudal vertebræ support chevron bones. 17. The teeth possess no true roots."

In 1877 Professor Owen[44] criticized these views of Cope, contending that the supposed ophidian characters do not really exist in the Mosasauria, summing up his conclusions with the statement that "The fossil evidences of the Mosasaurians hitherto made known do not yield a single character peculiar to and characteristic of the ophidian order." He contended that the Mosasaurs are aquatic Lacertilia, holding a position similar to that of the pinnipeds among the true carnivora.

In his reply to this paper Professor Cope[45] gave the following characters as essential in the definition of the order, which he still contends is valid: "1. The parietal bones are decurved on the sides of the cranium, and are continuous with the alisphenoid and prootic elements. 2. The opisthotic is largely developed, and extends upwards and forwards to the walls of the brain-case. 3. A distinct element connects the squamosal with the parietal bone above the opisthotic. 4. The teeth have no roots. 5. There is no sacrum. 6. There is no sternum. 7. The bones of the limbs possess no condylar articular surfaces.

"Of the preceding seven characters, the decurvature of the borders of the parietal bone at the margins, and their continuity with the margins of the prootic bones, is of importance as a character not found in the Lacertilia and universal among Ophidia. The opisthotic has a greater development than in lizards, where it does not reach the brain-case upward. In the serpents, its contact with the brain-case is well known. The existence of another element lying on the opisthotic, first pointed out by Marsh, is an important character. The anterior extremity of this bone enters into the side wall of the cranium below the parietal, occupying much the position of the pterotic, and resembling, even more than the opisthotic, the suspensorium of the Ophidia. Should this be the true homology, the affinity to the Ophidia is not strengthened; and should it prove

44. On the Rank and Affinities in the Reptilian Class of the Mosasauridæ, Gervais, Quart. Journ. Geol. Soc., 1877, 682.

45. Cope, E. D., Professor Owen on the Pythonomorpha, Bull. U. S. Geol. and Geogr. Surv. Ters., IV, No. 1, Washington, 1878, pp. 299–311.

to be a distinct element, not found in either Ophidia or Lacertilia, the claims of the new order to existence are maintained. In either case it is clear that the ophidian suspensorium is not the squamosal bone."

Unfortunately in these characters given by Cope there are several errors. There is no distinct element connecting the "squamosal" (prosquamosal) with the parietal bone above the opisthotic. There is the same kind of a sternum present as in the Lacertilia. The characters then left are the decurvature of the parietal bone, the absence of true roots to the teeth, and the absence of a sacrum. The last character is also incorrect, since in some of the forms, at least, there are as distinct articular condylar surfaces as in the Lacertilia. To the decurvature of the parietal bone no great importance can be attached. The absence of a sacrum and the natatory character of the limbs are really the most important of all the characters adduced, and, I believe, certainly entitle the Mosasaurs to an independent group among the Lacertilia. Among the last to criticize the classification of Professor Cope is Baur,[46] who reviewed the whole history of the controversy, described and figured the bones of the skull in an excellent way, and gave the following classification:

PLATYNOTA.

Superfamily **Varanoidea.**
Families ***Varanidæ.***
Mosasauridæ.
Superfamily **Helodermatoidea.**
Family ***Helodermatidæ.***

"I see no difficulty in assuming that the Mosasaurs developed from unguiculate Lacertilia, which were very close to the Varanidæ. To express this affinity, I placed the Varanidæ and Mosasauridæ in a superfamily, the Varanoidea. By this I wanted to say that the Mosasauridæ cannot be separated from the true Lacertilia, to which the Varanoidea belong; in other words, that they cannot be placed as a suborder of the Squamata, but have to be placed among the suborder Lacertilia. In this opinion I have nothing to change."

46. Science, Nov. 7, 1890, and Journ. of Morph., VII, p. 1, 1892.

Baur does not insist upon uniting the Mosasaurs in the same ultimate division as the rest of the Lacertilia, or any of the living forms, but does insist that they be placed under the Lacertilia.

In criticizing the first of these papers by Baur, Boulenger, the distinguished herpetologist, took the position, with Cope, that the Pythonomorpha constitute a distinct suborder of the Squamata, basing his views chiefly upon the limbs. He says: "Does this mean that limbs as strongly modified as those of the Monitors can have been modified into the paddles of the Mosasaurs? A glance at the figures suffices to refute such a theory." He defined the Pythonomorpha as having "nine or ten cervical vertebræ. Extremities paddle shaped, with hyperphalangy." In the three Kansas genera of the Mosasaurs described in the present work there are never more than seven cervical vertebræ. While hyperphalangy does occur among the Mosasaurs, there are some forms in which this is so in only a slight extent or not at all. In all the forms the "fifth metatarsal is reduced in length and strongly modified," another lacertilian character given by Boulenger.[47]

The latest definition of the Pythonomorpha given by Cope[48] is as follows:

> Alisphenoid modified as epipterygoid or wanting, leaving brain-case open; parietals flat; an interclavicle and clavicle; teeth with dentinal roots, *Lacertilia.*
>
> Epipterygoid present; parietals decurved, partially inclosing brain-case; no clavicle nor interclavicle; teeth with osseous roots..... *Pythonomorpha.*
>
> No epipterygoid; brain-case inclosed in front; no clavicle nor interclavicle; no fore limbs; teeth rootless..... *Ophidia.*

Dollo has recently affirmed the presence of a distinct interclavicle in the Mosasaurs, first discovered by Marsh. I have never seen such a bone in the material that has been accessible to me.

Following the foregoing papers and discussions appeared a paper by Dollo,[49] in which he summed up his views as follows:

"En résumé, je suis donc d'accord avec M. Boulenger pour regarder les Mosasauriens comme un sous-ordre distinct des *Squamata.*

47. Boulenger, Notes on the Osteology of *Heloderma horridum* and *H. suspectum*, with Remarks on the Systematic Position of the Helodermatidæ and on the Vertebræ of the Lacertilia, Proc. Zool. Soc. Lond. 1891, pp. 109-118.

48. Syllabus of Lectures on Geology and Paleontology, pt. III, 45, 1891.

49. Bulletin Soc. Belg. de Geol., VI, 251, 1892.

"Je pense, comme lui, que les Lacertiliens *actuels* (même les *Varanidæ*) sont trop spécialisés pour representer la souche des Mosasauriens.

"Je crois, comme mon collegue du British Museum, que cette souche nous est fournie par les Dolichosauriens.

"Mais je ne puis admettre que ceux-ci soient les ancêtres des Lacertiliens, des Ophidiens, et des Rhiptoglosses."

Of course no one can for a moment suppose that the Mosaaurs have not descended from terrestrial fissiped reptiles. The great variations in the type of the limbs among the Mosasaurs do not permit such exact comparisons as M. Dollo makes.

The latest discussion on the affinities and systematic position of the Mosasauridæ will be found in the papers cited below[50] by Professors Cope and Baur, dealing especially with the elements supporting the quadrate. This controversy in brief was, on the part of Cope, that the paroccipital was a distinct element, and not fused with the exoccipital, which did not support the quadrate at all. Baur contended that the paroccipital was fused with the exoccipital, and that the separate element called the paroccipital by Cope is in reality the squamosal. Further, Baur contended that the exoccipital of Cope, his paroccipital, did not at all support the quadrate, in the Iguanidæ, while Cope asserted that such was always the case. It is true that in *Varanus* the exoccipital of Cope does, in a measure, support the quadrate to a greater degree than I have ever observed among the Moasaurs. It is also true that the exoccipital (Cope) does in many cases help form the quadrate articular surface in the Mosasaurs.

The more important cranial differences from *Varanus* are as follows: The premaxillary of *Varanus* is flattened, and the conjoined nasals are united by a distinct suture. There are eight premaxillary teeth. The nares are much larger, the prefrontals smaller, the palatines smaller, and its anterior process longer. The lachrymal bone is larger. There is a supraciliare present, wholly wanting in all Mosasaurs. The frontal bones are united

50. Cope, Amer. Nat., Sept. 1895; Nov. 1895, p. 1003; Febr. 1896, p. 147.
Baur, Amer. Nat., Nov. 1895, p. 998; Febr. 1896, p. 143; Apr. 1896, p. 327.

by suture. The jugal is incomplete. The transverse bone unites with the maxillary and jugal. The pterygoids are without teeth. The basipterygoid processes are longer and the pterygoids, hence, much more widely separated. The basioccipital processes are much smaller; the exoccipital elements larger. The quadrate is more slender and has no suprastapedial process. The splenial and presplenial interdigitate and do not unite by a distinct articulation, the presplenial extending much further proximally and articulating with the coronoid. The sides of the parietal bone are not decurved to form the sides of the brain case anteriorly. There is a frontal subrhinencephalic bridge.

COMPARATIVE ANATOMICAL DESCRIPTIONS.

The skull, in the Kansas forms of the Mosasaurs, is elongate, wedge-shaped, and flattened. The external nares are elongated slits, with an anterior dilatation, and separated from each other by the slender prolongation of the premaxillary and the coossified nasals, and, at the posterior narrowed extremity, by the anterior end of the frontals. Externally they are bounded by the prefrontals and maxillæ. The orbits are irregular in outline, broader from in front back than from above downward. Their plane is outward, with a superior and anterior obliquity. Their free margins are composed of the prefrontals, usually the frontals for a short distance, the postfronto-orbitals, the jugal, and the lachrymal. In *Clidastes*, and, in a less degree, in *Mosasaurus*, the upper part of the orbital cavity forms part of the superior plane of the skull, covered over, in life, by membrane, and supported by the projecting prefrontals, which here functionally replace the supraciliare of *Varanus*. The frontal bone is nearly plane and is unpaired, though there is an indication in all, but especially in *Tylosaurus*, of the original division into two bones, anteriorly. The supratemporal fossæ, directed upwards, are large, bounded externally by the postfronto-prosquamosal arch, posteriorly by the parieto-squamosal arch. A pineal foramen is always present, is usually large, and situated near the anterior end of the unpaired parietals. The jugal arch

is complete in all the known forms, forming the posterior and inferior border of the orbit. Below, on the inner side, it is suturally attached to the transverse bone, which does not reach forward to the maxilla, or so only to a very slight extent. The parietal sends down on each side a flattened, wing-like process for union with the petrosals and supraoccipital, bounding the brain cavity externally in part.

The posterior aspect of the skull presents an elongated opening below the parietal arch, bounded below by the conjoined exoccipital and paroccipital and above by the parieto-squamosal arch. The teeth exist in a single row on the maxillæ, mandibles, and pterygoids, and in a double row of four on the conjoined premaxillary. The vomers are elongated bones of the palate attached anteriorly to the premaxillary and maxillary, posteriorly to the anterior elongation of the palatines. The crowns of the teeth are simple, conical, and recurved, sometimes nearly round in cross-section, at other times flattened oval with a posterior and anterior cutting carina, the surface elsewhere smooth, or narrowly faceted and striated. The crown is attached to a spheroidal mass of ostein, which is not, however, a true root, and which projects beyond the margin of the bones in which they are inserted in a cavity. This base is an ossification of the tissue surrounding the blood-vessels and nerves, and is frequently dislodged entire from the jaw. On the inner side posteriorly of this base there is usually a smaller excavation, in which the young tooth may be found. Rarely is a jaw seen in which all the teeth are complete. Some will be lost, showing only the empty cavity of the socket, while others will be found in different stages of growth. The crown is covered with enamel. The teeth of the pterygoids are smaller, sometimes much smaller, than those of the jaws, and are usually more curved.

The posterior flattened portion of the palatines articulate closely with the posterior end of the maxillæ on the outer side, the anterior thinned portion of the pterygoids on the inner, the vomers anteriorly, and the descending process of the prefrontal on the superior side posteriorly. Between the anterior process

and the maxilla, on either side, there is a long, narrow vacuity, situated in part below the external nares. The palatines curve downwards to articulate with the pterygoids, so that the teeth of the latter are in a lower plane than those of the maxillæ.

The pterygoids are elongate, curved bones with four processes. The anterior, obliquely flattened process articulates with the inner side of the palatines and is separated narrowly from its mate at the extremity. The ectopterygoid process, thicker and stouter, is directed somewhat upwards, its rugose and dilated extremity attached to the transverse bone. The dentigerous portion is prolonged into a small, flattened process, which lies under the basipterygoid process of the basisphenoid, nearly in contact with that of the opposite side and close to the under surface of the basisphenoid. The long, flattened, involute posterior process is curved outward and downward to articulate with the inferior inner angle of the quadrate. Its roughened end fits closely to a corresponding surface on the quadrate, and, while the union may not be rigid, it cannot admit of much motion.

In the following detailed descriptions I have used for comparison skulls of *Clidastes velox*, *Platecarpus coryphæus*, *Mosasaurus horridus*, *Tylosaurus proriger*, and an incomplete one of *Brachysaurus overtoni*:

Premaxillo-nasals.

Clidastes velox. The premaxillary is characteristic of the genus. The anterior, expanded portion is about as long as wide, forming a broad, short cone, extending only a short distance in front of the teeth, with the apex rather sharp. The borders for articulation with the maxillæ pass inwards obliquely, the width of the superior surface between the maxillæ to the anterior end of the nares being nearly equal throughout, the sides almost parallel. The surface is lightly and delicately sculptured above, with an obtuse, low, median convexity. At the beginning of the nares, the superior surface rapidly narrows to form a vertical plate separating the openings. At the posterior extremity the conjoined nasals dilate to overlap the narrow anterior projection of the frontal. On the under side there are

four teeth, the anterior pair smaller than the maxillary teeth and approximated. A median ridge separates the teeth, and is continued into a stronger one back of them. Between the two narial openings the inferior border is thin, and is wholly or largely hidden by the approximated vomers. The bone articulates with the maxillæ, vomers, and frontal.

Mosasaurus horridus. The tip of the rostrum is rather more obtuse than in the previous species, but not as much so as in the following, projecting a short distance beyond the teeth. The portion in front of the maxillæ is about as long as wide, nearly semicircular in cross-section, with a shallow longitudinal groove in the middle above, in place of the obtuse carina. This groove reaches to about the beginning of the nares. The lateral margins above are very long and oblique, resembling in this respect *Tylosaurus* more than *Clidastes*. The opening of the nares is opposite the fifth maxillary tooth.

Platecarpus coryphæus. Pl. XXVI, ff. 2, 3. The premaxillary is short and obtuse, differing markedly from the other genera in not projecting at all beyond the teeth, the tip often with a distinct depression, instead of a convexity or cone. It is smoothly convex above, without median ridge or convexity. The sutural union for the maxillæ runs nearly obliquely from the dental border back to the anterior end of the nares, very unlike what it is in *Clidastes*. The internarial process is narrow and oval in cross-section for a short distance before the middle of the nares. Posteriorly it widens uniformly into a thin, flattened plate, the conjoined nasals, which overlie the anterior prolongation of the frontal, the suture nearly opposite the posterior end of the nares. The nares are much shorter relatively than in *Clidastes*.

Tylosaurus. The premaxillo-nasal in *Tylosaurus* is one of the largest elements of the skull, and is very characteristic of the genus. It forms a long, obtuse projection in front of the teeth, the edentulous portion being considerably longer than the dentulous. It is smooth and rounded, nearly circular in cross-

section in front of the teeth, the tip obtuse. The teeth are relatively smaller than in the other genera. Just back of the posterior pair the sutural border runs a short distance rectangularly upward. From this angle, the sides run obliquely backward to the anterior angle of the nares. The intermaxillary portion is very broad and long, more than twice as wide in front as behind. The surface above throughout is convex and smooth, without carina or depression. Posteriorly, to the anterior end of the nares, the internarial portion narrows rapidly, but is much thicker and stronger in the narrowest part than is the case in either of the other genera. The conjoined nasals broaden as in the other genera to overlap the anterior end of the frontal, but extend much further back, beyond the nares. The free internarial portion of the conjoined bone is only a trifle longer than the intermaxillary portion. On the under side the ridge separating the anterior teeth divides at their posterior part into two branches, between which are inserted the thin, vertical and contiguous anterior ends of the vomers. The thin plate or ridge continues on each side into a tongue-like process, vertically flattened and suturally united in a shallow groove on the outer side of each vomer as far back as the posterior part of the second tooth, articulating on the inner side of the maxilla at the base of the first tooth.

Vomers.

The vomers in *Mosasaurus* are very slender, and are in apposition throughout, or for the most part. Near the front end, the short, vertical, articular face unites with the maxilla opposite the second tooth. Just back of the articular surface there is a small elongate oval opening left on each side between the constricted vomer and the emargination of the horizontal plate of the maxilla. The vomers, as far back as the eighth or ninth teeth, are very narrow below, the surfaces somewhat obliquely placed. Posteriorly they seem to join by a long, squamous suture with the anterior prolongation of the palatines.

The vomers in *Clidastes* are evidently quite like what they are

in *Mosasaurus*. They articulate with the premaxilla to a very slight extent only at the tip. The suture between them and the palatines is indistinguishable.

In *Platecarpus* the vomers resemble those in the two preceding genera. A view of the anterior outer side is shown in pl. XIX, f. 4, giving the articulation with the maxilla. In none of the three genera is there any indication of the long, tongue-like process of the premaxillary, as described below, and no distinct surface for union with the premaxilla. The emargination back of the articular face is longer and deeper in the horizontal maxillary plate of this genus.

The vomer in *Tylosaurus* is very much elongated, as in *Mosasaurus*. Anteriorly it ends in a thin vertical plate lying contiguous with its mate and inserted between the two plates of the premaxilla on the under side, as described for that bone. On the outer side, as far back as the middle of the second maxillary tooth, it has a shallow longitudinal groove for articulation with the thin, vertical, tongue-like plate of the premaxilla. The articulation with the maxilla extends back of this as far as the middle of the fourth maxillary tooth, presenting an elongated sutural surface. Posterior to this articulation the bone is constricted as in the other genera to form the anterior palatine foramina, which lie below the anterior end of the nares, and thence gradually widens, standing nearly vertically. The union with the palatines is so close that it cannot be distinguished, the bones continuing in the same line and in apposition nearly as far back at the anterior end of the dilated portion of the palatines. In the posterior part the bones slope outward from the middle line, where they are in close contact, inclosing a long, slender, oval opening between them and the maxillæ, in large part below the external narial opening. Just back of the maxillary articulation the bones diverge a little for a short distance to show the inferior border of the premaxillary, and the under surface here shows an oblique groove running backwards and outwards, as though for the passage of a nerve or blood-vessel.

Maxillæ.

Clidastes velox. The maxillæ have fifteen or sixteen teeth, the last one in the latter case small. The inner side has a strong longitudinal ridge, emarginate anteriorly, for the anterior palatine foramen, with a groove or cavity above it, arched over by the flattened upper part of the bone. The borders for union with the premaxillæ, back of the vertical part, are nearly parallel to each other in the skull. The narial openings are elongated and narrow, the maxillary border thin, with a deep emargination in front. Posteriorly here is a small, flattened process overlapping the prefrontal on the upper surface of the skull. The posterior end terminates in a slender, pointed projection, partly covered over above by the jugal. On the outer side there are fifteen dental foramina above the teeth, and some smaller ones anteriorly. The bone articulates with the premaxilla, vomer (turbinate?), palatine, prefrontal, jugal, and lachrymal. The border for the palatine is thinned, beveled, and roughened, extending as far forward as the fourth tooth from the end. The border for the jugal is straight and thin, reaching as far forward as the antepenultimate tooth. Below this border on the inner side there is a narrow and deep excavation. The articular surface for the vomer is short and small, very near the anterior end of the bone, on the front extremity of the inner ridge and above the first two teeth. Just above this surface posteriorly there is a small, smooth depression.

The maxillæ of *Mosasaurus horridus* have fourteen teeth. The bone is narrower than in *Clidastes*. The beginning of the nares is opposite the sixth tooth. The nares are much elongate, reaching beyond the posterior end of the nasals.

Platecarpus. Pl. xxv, ff. 1, 2. The maxillæ are stouter and shorter than in *Clidastes*. The border for the articulation with the premaxillæ runs nearly straight and obliquely to an obtusely rounded point, which is separated by only a short space from the one of the opposite side, just before the beginning of the nares. The free border back of this is thickened, rounded, and deeply emarginate anteriorly. From the posterior end of

this emargination the inner upper part of the bone overlies broadly the sides of the prefrontal. Posteriorly this border ends in a small, tongue-like projection on the prefrontal, outside of which the margin is continuous with the pointed posterior extremity of the bone. There are twelve teeth. The articular surface for the vomer is situated further back than in *Clidastes*, nearly over the third tooth, and the emargination for the palatine foramen is much larger, reaching to beyond the fourth tooth. The surface for union with the palatine is shorter.

Tylosaurus. The maxilla of *Tylosaurus* is intermediate in length and breadth between those of *Clidastes* and *Platecarpus*. The maxillary suture extends as far back as the sixth tooth, and is much longer than in either of the other genera. Back of this the emargination for the anterior part of the nares is less deep than in *Platecarpus*. The prefrontal process is rather larger than in *Platecarpus*, the posterior extremity more slender. The sutural surface for the vomer is situated further back than in *Platecarpus;* that for the palatine is nearly the same. There are thirteen teeth.

Brachysaurus overtoni. Pl. XXII, f. 1. The maxilla in *Brachysaurus* is very massive and stout. The border for the premaxilla is very short, extending back as far as the third tooth only, the vertical portion only a little shorter than the oblique portion. There are ten, probably eleven, teeth, implanted on prominent, broad bases.

Prefrontals.

Clidastes. The prefrontal is the most characteristic bone of the *Clidastes* skull, varying somewhat in the different species. It is elongate and flattened on the upper surface, with striations and markings like those of the frontal on whose plane the horizontal portion is. It projects strongly over the orbits in front, serving functionally in place of the supraciliare of the *Varanus* skull. The inner border is concave to correspond with the border of the frontal. The outer border is free, nearly straight, and lightly rugose for nearly half its length, protruding horizontally. On the inner side anteriorly the bone forms a

short part of the free border of the nares, anterior to which the thin expansion is overlapped by a flattened process of the maxillary. The maxilla also overlaps the outer part of the bone on the anterior third. The horizontal part is considerably thickened posteriorly, with the under side of the hind border beveled and slightly concave. A broad, flattened process at the posterior interior part underlaps the frontal, being received in a pit or depression of that bone. A thick, curved, wing-like process is sent down on the outer side, curving inward to form the very convex anterior border of this orbit, and articulating below with the jugal, lachrymal, and, on the inferior surface, with the posterior end of the palatine. It articulates with the frontal on the inner side, the maxilla in front and on the side anteriorly, the lachrymal and jugal behind, and the palatines below.

Mosasaurus horridus. The prefrontal of *Mosasaurus* is quite as peculiar as that of *Clidastes*. The horizontal part, or wing, over the anterior part of the orbit, is semicircular in shape, with lightly crenulated edges. In front of this there is an emargination or groove with rounded border connecting the superior and lateral faces. This semicircular supraciliary plate served the same purpose as the posterior flattened part in the *Clidastes* bone. Were it removed the bone would not be unlike what it is in the two following genera. Between this supraciliary plate and the postfrontal there is a rather sharp triangular notch, evidently filled in with membrane in life. The bone touches the postfrontal behind.

Platecarpus. Pl. xxv, f. 3. The prefrontal, as seen in the articulated skull of *Platecarpus*, sends a long, slender process on the inner margin of the maxilla as far as the posterior end of the anterior emargination, its thin narial border being straight or gently concave. Posteriorly it has a thickened, irregular, very narrow horizontal projection along the frontal orbit, corresponding to the semicircular plate of *Mosasaurus* or the broad one of *Clidastes*. Behind this it reaches back nearly or quite as far as the postfrontal, though scarcely visible from above. Inferiorly it sends down a much smaller process for union with the palatines.

Tylosaurus. In *Tylosaurus* the superior surface of the prefrontal is elongate triangular in shape. The anterior end is overlapped broadly by the broad, tongue-like process of the maxillary, which may even reach to the frontal, wholly excluding the prefrontal from participation in the nares. Posteriorly it reaches, narrowly, quite to the anterior prolongation of the postfrontal. Outwardly it reaches downwardly, broadly, to the thin margin of the maxilla, leaving a triangular space posteriorly in which the lachrymal is articulated. In front of the orbit the nearly vertical surface turns inward, broadly, as in the preceding, to the margin of orbits. In the horizontal development of the posterior part of the prefrontal, the greatest is that of *Clidastes*, the least of *Tylosaurus*, with *Mosasaurus* and *Platecarpus* respectively intermediate.

Lachrymal.

The lachrymal bone is present in the different genera, but seems to differ slightly. It is least distorted in a specimen of *Clidastes*, where it is a small, somewhat irregular, pointed bone, with an articular surface along the sides, and at the larger extremity is grooved along one side; it is smooth above, and is slightly roughened on the outer side. It is attached in the interval between the jugal and the prefrontal, and articulates in part with the maxilla. It enters into the lower part of the anterior border of the orbit.

Frontal.

The frontal bone in *Clidastes* is elongate and slender in comparison with that of the other genera. The lateral borders have a long and deep concavity from near the posterior angles of the bone to near the anterior third, whence the sides approach each other more rapidly, or wedge-like, to near the posterior ends of the narial openings. The posterior border is transverse, with an undulatory or zigzag outline, the middle not being appreciably emarginated for the parietal bone. The upper surface is flattened, gently convex in the middle, and with a low, rather obtuse median carina on the anterior third. The free orbital border is short, obtusely edged, and forms a part of the lateral

concavity of the bone. On the under side there are two prominent ridges, bounding the cavity for the olfactory lobes. On the anterior part this cavity is separated into two by a median ridge; nearly opposite the posterior extremity of the maxilla the ridges bounding the cavity approach each other, the excavation continuing as a narrow, deep groove to about opposite the middle of the orbital margin. At the outer side of these ridges the bone is excavated for the sutural union of the prefrontals. At the beginning of the narial opening the bone rapidly narrows and is thinned for union with the nasal. In this part the bone is imperfectly united in the middle. The nasals reach no further than the posterior end of the narial openings. The bone articulates with the parietal, postorbital, prefrontal, and nasal.

Mosasaurus horridus. The frontal bone in *Mosasaurus* is much broader than in *Clidastes.* Posteriorly it has two slender processes inclosing the narrow anterior projection of the parietal, in which is the pineal foramen. The sides are nearly straight, and gently convergent to a strong and sharp emargination for the prefrontal anteriorly. Its connection with the nasal cannot be made out with certainty, but it is evidently not posterior to the narial openings. The bone is nearly plane, sloping gently, and with a low, obtuse carina in the middle anteriorly.

Platecarpus. Pl. XVI, ff. 2, 3. The frontal bone is broader than in *Clidastes.* Posteriorly it is broadly and deeply emarginate for the parietal, outside of which the margins are nearly straight to the angles. From near the angles the lateral margins are concave for nearly half their distance to the nares, somewhat thickened on the orbit, which is thickened for a short distance, as seen from above. Beyond, the sides are irregular and gently convex to unite with the prefrontals. From a little back of the middle of the bone there is a thin, sharp, median carina, highest in its middle portion; on either side of the carina the bone is shallowly concave. On either side in front there is a small, tooth-like process underlying the posterior process of the maxilla, the notch between it and the inner bor-

der forming the posterior angle of the nares. This process is wholly wanting in *Clidastes*. On the under side the prefrontals are more widely separated and the olfactory groove more gradually widened. The bone is considerably wider at posterior end.

Brachysaurus overtoni. The frontal bone in this species is remarkably broad and stout.

Tylosaurus proriger. In *Tylosaurus*, the frontal is broader relatively than in *Platecarpus;* the sides above the orbits are nearly straight and parallel, and wholly excluded from the orbits. From the posterior third the sides gradually converge in nearly a straight line to the tooth-like process at the posterior end of the nares. In front of the middle the bone is convex in the middle part but is not carinate. Anteriorly the two halves of the bone are unossified, the division represented by a median groove above. Posteriorly the deep median emargination for the parietal is wanting. In shape the bone is more nearly triangular than in the preceding species. On the under side the prefrontals are more narrowly separated than in *Platecarpus*.

Postfronto-orbitals.

Clidastes. The postfrontal and orbital are closely united, without trace of suture. It extends along the outer border of the frontal for a short distance, its outer border curving outward and downward to the jugal process. The stout, thickened process for lateral union with the parietal extends only a little inwards, forming the outer anterior angle of the supratemporal fossa. The jugal process is broad and flat and is directed nearly downwards. Back of the process the bone narrows to a flattened oval shape in cross-section, the under side of which is inserted into a groove in the prosquamosal. The bone extends nearly to the articular surface for the quadrate. The broad squamosal plate underlies the frontal, articulating for nearly a third of its width. It articulates with the squamosal (sometimes), the prosquamosal, parietal, jugal, and frontal.

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Mosasaurus. The postorbito-frontals in *Mosasaurus horridus* extend forwards to touch the posterior end of the prefrontal, leaving a triangular notch in the roof of the orbit. The posterior process is wedge-shaped, and, posteriorly, instead of being inserted in a groove in the squamosal, it divides that bone in two, one part of which lies on the inner and the other on the outer side below.

Platecarpus. Pl. XXIV, f. 4. In this genus the postfrontal touches, or nearly touches, the prefrontal, instead of being separated by a considerable space as in *Clidastes.* The jugal process is longer and flatter. The posterior projection, lodged in a groove on the upper part of the prosquamosal, extends back to beyond the anterior end of the articulation for the quadrate. The bone does not articulate with the squamosal at all, and the prosquamosal reaches as far forward as the descending process for the jugal.

Tylosaurus. In *Tylosaurus* these elements are nearly as in *Platecarpus,* except that the bone extends forward, quite to the prefrontal, forming a very narrow margin to the orbit posteriorly. The jugal process is rather shorter, and the articular surface for the prosquamosal reaches quite to that for the jugal, the two bones touching each other, which does not occur in *Clidastes.* The bone underlaps the frontal broadly, forming a subtriangular surface.

Jugal.

Clidastes. The jugal is a slender, curved rod, with an articular surface at either extremity. It is nearly circular in cross-section posteriorly and flattened anteriorly. The curvature begins near the middle, and is nearly regular. The anterior half is only slightly concave on the upper border. The excavation for the maxilla is on the inferior inner side, and reaches nearly a third of the length of the bone. At the anterior dilated extremity the bone articulates with the lachrymal above. The posterior extremity is somewhat thickened, though not much dilated, and unites with the short jugal process of the postfrontal. The bone has no tubercular process on the posterior

border, as is found in the following forms. There is usually a small articular surface situated far back on the inner side, at the margin of the greater concavity, for union with the ectopterygoid.

Platecarpus. Pl. XXIV, f. 5; pl. LXIII, f. 3. In this species the jugal is a stouter bone than in *Clidastes*, but not as stout as in *Tylosaurus*. It is somewhat L-shaped in form, with the horizontal arm slender and curved downward. The upright arm is flattened obliquely, and deeply excavated above on the outside for the jugal process of the postfrontal, the excavation reaching more than half the distance to the angle of the bone. Its posterior superior angle is thickened, and unites with the prosquamosal. Where the bone begins to curve forward there is a prominent tubercle on the outer hind margin, as if for ligamentous attachment, and the bone is channeled obliquely inward in front of it. The anterior branch is dilated and flattened at the extremity, and excavated into a groove on the under side for articulation with the posterior end of the maxilla. At the posterior end of the horizontal arm in front of the angle, on the inner side, there is a depressed sutural surface, of variable length, for union with the ectopterygoid.

Tylosaurus. In *Tylosaurus* the jugal is a stouter bone than in either of the other genera. It is bent more nearly in a right angle than in *Platecarpus*, and the anterior prolongation is less slender, the end less dilated. The upper ramus is broader and flatter, and less deeply excavated for the jugal process of the postfrontal. The angle below is broadly rounded, the margin is thinner, and not produced into a tubercular process; instead of which, there is, on the outer side, a roughened depression of considerable size for the insertion of a strong ligament or tendon. The vertical arm is set more obliquely and the surface is concave transversely. On the inner border there is a roughened, elongate spot for the transverse bone. The horizontal arm is flattened and much stouter than in *Platecarpus*. The beveled and grooved articular surface for the maxilla is on the inferior inner side, and extends far back. The bone runs to a narrow

extremity anteriorly, different from the expanded and flattened extremity in *Platecarpus*. Altogether, the jugal, as already stated, is a stronger element, with stronger muscular attachments, than in either of the other genera. Judging from the differences which these three forms present, it is not at all unlikely that in some forms of the group the jugal may exist in a rudimentary condition, as in *Varanus*.

Pterygoid.

Clidastes. The pterygoid is an elongate bone, with four, more or less elongated, processes. The posterior process is broad, flattened, and nearly vertical, with a short, emarginate articular surface at the extremity, for union with the inferior, anterior inner part of the quadrate. Its under border is markedly convex distally, the upper border thicker and concave. From the base of this process the ectopterygoid process is directed outward and upward, its posterior border continuous with the superior border of the quadrate process. The process is flattened, oval in the middle, and somewhat dilated at the extremity for union with the ectopterygoid; it is placed obliquely, so that the anterior superior border is continuous with the upper inner border of the body of the bone. Directed nearly backward and a little outward is a short, pointed process, which I will call the basisphenoid process, inclosing between it and the quadratal process a deep notch for the articulation of the basipterygoid process of the basisphenoid. On the upper side, at the anterior extremity of this notch, there is a small pit for the inserting of the lower end of the epipterygoid. The anterior process is thin and flattened and unites with the posterior inner angles of the palatines, the free margin continuing on the inner side to a point which is less broadly separated from that of the opposite side than the bones are posteriorly. The teeth are twelve in number—greater than in any other genus of the group.[51] The anterior ones are larger than the posterior, and they are all rather closely crowded together. They are moderately flattened, with a distinct carina. They are bordered internally by

51. Merriam gives the number at twelve to fifteen, but I have never seen more than twelve.

a more or less sharp ridge, but they are never pleurodont or protected by a parapet, a character that has been given for distinguishing the genus *Edestosaurus* from *Clidastes*, but which is of no value whatever.

Mosasaurus horridus. The pterygoids in the type specimen of this species are in position and undistorted, while those of *Clidastes* are invariably more or less distorted. They are evidently very closely alike, and present characters that readily distinguish the bone from the same in the other subfamilies. The anterior end terminates in a broad plate on the inner side, which slopes markedly toward the middle. There are eight teeth in a single curve, whose concave side is internal and reaching from before the posterior end of the palatine, and opposite the last maxillary tooth, to the base of the basisphenoid process. The teeth back of the palatine stand very nearly on the outer edge of the bone on a convex surface, and are not all pleurodont. The basisphenoid process is longer than in *Clidastes*. The ectopterygoid process is placed like that of *Clidastes*; that is, obliquely. Its posterior border is continuous with the inferior border of the quadrate process, while the anterior is continuous with the superior interior border of the body of the bone, inclosing a long, shallow groove between its base and the part on which the teeth are inserted. In *Platecarpus* and *Tylosaurus* the process is nearly horizontal, and its anterior border is continuous with the outer border of the bone, or nearly so. The bone differs from that of *Clidastes*, in the lesser number of teeth (eight) and in the less expanded inner side anteriorly.

Platecarpus. Pl. XXIV, f. 1. The pterygoid of *Platecarpus* has ten teeth arranged in the form of a reverse curve. The teeth extend into the base of the basisphenoid process, which lies closely in the depression on each side of the lower surface of the basisphenoid. The quadrate process is nearly vertically flattened or gently concave on the inner side, narrower and stouter at the base, obliquely truncate and roughened at the tip for union with the quadrate. The under border of the dilated portion is strongly convex. Nearly opposite the base

of the ectopterygoid process on the upper side in front of the notch between the quadratal and basisphenoid process there is a rounded pit for the epipterygoid. The ectopterygoid process is much dilated obliquely at its extremity, sometimes dilated near its base in front so as to constrict the inclosed notch. The palatine process is flattened, ending in a narrower extremity. The teeth begin posterior to the end of the palatine. The teeth are small, much curved, somewhat flattened and striate.

Tylosaurus. In *Tylosaurus* the pterygoid resembles that of *Platecarpus.* The anterior dentigerous portion is stouter and less flattened, the part in front of the teeth for union with the palatines thinner and less broad. The teeth begin further forward, as in *Clidastes*, and not back of the palatines. The ectopterygoid processes are relatively stouter and less contracted at the base. The basisphenoid process is broader and shorter, and the teeth do not extend as far as its base, while in *Platecarpus* they reach two-thirds of the distance to its tip. The quadratal process is less expanded distally, and is relatively shorter than in *Platecarpus.* The bone altogether is less slender. There are ten teeth.

Parietal.

Clidastes. The coossified parietals have a broad, anterior, transverse border, concave sides, limited by sharp margins, the parietal crests, and long, thin, flattened parieto-squamosal processes, reaching outward and backward from the posterior angle to the outer part of the suspensorium. Posteriorly, on either side, the upper surface is continued into a pointed projection, which forms the upper margin of the base of the parieto-squamosal process. The margin in the middle behind is thinned, rugose, beveled, and with a notch in the middle. Anteriorly the stouter lateral processes or wings pass outward to form the anterior lateral border of the supratemporal fossæ, connecting with the postfrontals. They are convex from above downwards, and limited on the inner part by a sharp overhanging ridge, the beginning of the parietal crests. The pineal foramen is small, and situated a short distance back of the front margin of

the bone. On either side, the bone sends down a broad, deep wing to form the upper part of the sides of the brain-case. At the most inferior part the border is projected into a thin, triangular process, the tip of which shows sutural roughening; their posterior margins are thin, with an S-shaped undulation. From the sides this thin margin shows an obtuse angle near the middle, the upper part for union with the supraoccipital, the lower for the petrosals, or rather for the cartilage that completes the union between these two bones. The thin margin superiorly, is inserted in the groove of the supraoccipital, as described below. Between the upper extremities of these thin margins the under surface of the bone is more or less roughened, or with spinous sutural projections for attachment to the crest of the supraoccipital. The posterior processes are thin, flattened, and arch outwards, backwards and downwards to unite with the long process of the squamosal by a long suture on the under side. The superior surface between the crests has nearly parallel sides. The bone articulates with the frontal, postfrontal, petrosal, squamosal, and supraoccipital.

Mosasaurus. The superior surface of the parietal continues back more narrowly than in *Clidastes*, with a divaricated process on either side of the posterior notch.

Platecarpus. Pl. XXVI, f. 1; pl. LXIII, f. 1. The parietal fits into a broad emargination of the frontal. From the posterior angles of this emargination, the sharp borders of the superior surface, or the parietal crests, run nearly straight to an apex a little beyond the middle of the bone, a character peculiar to the genus. The moderately large parietal foramen is situated a little back of the line of the suture, and usually wholly within the parietal bone. The lateral processes, forming the anterior boundary of the supratemporal fossa, reach out transversely to unite with the postfrontal a little within the angles of the frontal bone. The bone is narrowest opposite the apex of the superior surface.

Tylosaurus. The parietal in *Tylosaurus* is characteristic. Its upper flat surface has its sharp, lateral crests convergent to beyond the middle, and then parallel or gently divergent, the pos-

terior end terminating to divergent points, as in *Clidastes*. The anterior lateral wings do not extend as far outward, and the lateral margins, especially toward the front, are thinner and more projecting than in either of the other forms. The pineal foramen is rather small, and is usually wholly inclosed in the parietal, though it may border the anterior suture.

Supraoccipital.

Platecarpus. The supraoccipital is a little longer than wide, with a ridge upon the upper surface, terminating in a sutural surface for union with a median tooth or tongue-like projection of the parietal bone. In the region of the semicircular canals the brain cavity is narrowed by a swollen projection on either side, into which is continued, from the exoccipital, a small, round canal. Anteriorly the sutural surface for union with the petrosal continues as a straight, flat surface, inclosing, between the two, a broad cavity for the cerebrum. The upper border, meeting at an angle a little greater than a right angle with that of the petrosal, is a little shorter, and has a deep longitudinal groove, with the margins thin; the thin posterior margins of the descending wings of the parietal fit into these grooves. The bone articulates with the exoccipital, petrosal, and parietal, with the latter directly, in the middle, by the intervention of connective tissue on the descending part. It forms the superior margin of the foramen magnum, and extends outward, as a broad, flattened squama, for about an inch on the upper side of the base of the exoccipital.

Basisphenoid.

Clidastes. The basisphenoid, longer than broad, as seen from below, has the margins deeply concave, the ends nearly transverse. In front are three processes, the middle small and short, ending abruptly and transversely; two lateral ones truncate, flattened oval, and obliquely placed to the long axis of the bone. The former is the presphenoid, and has near its base on either side above a small, rounded surface, for cartilage, precisely as in *Varanus*. I have never seen the presphenoid bone in this genus, but in *Platecarpus* one similar to that of *Varanus*

is sometimes found, and in all probability it occurs in *Clidastes*. The lateral processes, the basipterygoid, are much shorter than in *Varanus*, and evidently are completed by cartilage, as they do not extend to the bottom of the notch for their reception in the pterygoids in the articulated skull. The posterior, basioccipital processes are squamous, underlying and closely united with the hypapophyses of the basioccipital, reaching nearly to their extremity. From above, the narrow, concave brain cavity is seen lying between the oblique, broad, sutural surfaces for the petrosal. On either side, under these overhanging sutural projections, there is a deep longitudinal groove, at the bottom of which, in front and behind, is the opening to the longitudinal canal. From the anterior opening of the canal a groove is continued anteriorly to near the tip of the presphenoid process. In front of the pituitary fossa the cerebral surface is narrowed to a slender groove, continued to the tip of the presphenoid process. The bone articulates posteriorly with the basioccipital, superiorly with the petrosals, and anteriorly with the pterygoids, the latter of course non-sutural in character.

Basioccipital.

Clidastes velox. The occipital condyle is moderately separated from the basioccipital processes by a distinct neck, and is chiefly formed by this bone. The neural surface is narrow, of moderate depth, with a depression near the middle, the "fossa mediana." The hypapophysial processes are stout, trihedral, directed downward and outward, and are overlapped on their whole anterior surface by the thinned posterior process of the basisphenoid. There is no median canal in any specimens of this or the other genera in the University collection. The bone articulates above with the exoccipitals, which extend downward on the outer side nearly to the extremity of the basal processes. In front the bone articulates with the basisphenoid, the anterior broadly rounded border of the inferior processes fitting into a depression on the posterior part of the basisphenoid. On the upper anterior angles there is a small surface for articulation with the petrosals.

In *Platecarpus* the exoccipital reaches to the margin of the cartilaginous surface of the basioccipital processes on the outer side anteriorly, and is broader here than in *Clidastes*.

In *Tylosaurus* the exoccipital reaches only a short distance downward on the sides of the hypapophyses, while the basisphenoid extends much further back on the inner side. The cartilaginous surface at the extremity of the hypapophysial processes seems to be more elongated.

Exoccipital.

Exoccipital and *paroccipital* of Baur; *exoccipital* of Cope. There has been not a little controversy over this element, or the distal part of it, by Professors Baur and Cope, which the reader may follow, if he chooses, in the references given below.[52] Baur holds that the bone called exoccipital by Cope, and which never shows a trace of division in this group, is in reality composed of the conjoined exoccipital and paroccipital. To avoid confusion, it will be desirable to give here the different names by which the elements of the cranial bar have been called by different authors in the Lacertilia:

Paroccipital, Baur.
Exoccipital, Cope.

Squamosal, Gegenbaur, Baur (1892), Merriam.
Mastoid, Cuvier, Owen.
Supratemporal, Parker, Baur (1887).
Opisthotic, Cope (1871).,
Paroccipital, Cope (1892).

Prosquamosal, Baur.
Quadratojugal, Gegenbaur, Baur (1889, 1892), Merriam.
Squamosal, Owen, Huxley, Parker, Cope (1871), Baur (1887).
Supratemporal, Cope (1892).

The element under discussion, whatever be its composition, is usually closely united with the petrosal (prootic), the two rarely being found disassociated. The stout suspensorium, composed of these two bones and the squamosal, is directed outwards, somewhat upwards, and backwards, articulating with the squamosal and quadrate. The line of union between the

52. Baur, Amer. Nat., 1896, pp. 143, 327; Anat. Anzeiger, x, 327. Cope, Amer. Nat., 1895, pp. 855, 1003; 1896, p. 147.

exoccipital and petrosal begins at the angle of the basioccipital bone, curves backward through the meatus auditorius, and thence toward the posterior margin of the distal extremity, lying on the front margin of the stapedial groove for nearly its whole length. The upper surface of the suspensorium is composed chiefly of the exoccipital. The bone unites broadly with the squamosal at its anterior surface side distally and sometimes helps form a part of the quadrate articular surface. As regards the relation which the exoccipital or paroccipital bears to the quadrate, Baur says: "The Mosasauridæ agree with the Iguana, etc., in not having any part of the articular face for the quadrate on the paroccipital"; Cope, that "the articulation of the quadrate in the Pythonomorpha is exclusively with the paroccipital [*i. e.*, squamosal] and the squamosal [prosquamosal]."

The fact is, that in some Mosasaurs both the paroccipital and squamosal of Baur, or the exoccipital and paroccipital of Cope, articulate with the quadrate, though the articular surface for the former is always less extensive than that for the latter.[53]

In *Platecarpus*, at least, there is an elongate, conical or pyramidal process intercalated between the exo-paroccipital and the petrosal, reaching nearly to the brain cavity. In nearly all of the rare cases in which the squamosal is separated from the suspensorium, this process is broken off from the body of the bone at the extremity of the petrosal, the strongly roughened surfaces appearing as though the bone terminated there, which is not the case. The elongated portion that is thus intercalated between the two bones is entirely excluded from the exterior, received in a depression on the anterior superior face of the exoccipital and completely overlapped by the petrosal. Internally, above, the suture of the supraoccipital extends outward in a thin, rounded plate, as far as the lateral margins of the condyle. The process extending downwards on the sides of the basioccipital hypapophyses is broad and long, reaching as far as the margin of the distal surface. Above, the short sutural surface for the petrosal, between that for the supraoccipital

53. This fact is also stated by Baur: "The lower and distal part of the paroccipital process joins the quadrate." Journ. Morph., VII, 12, 1892.

and the basioccipital, is largely excavated for the semicircular canals. The sutural surface for the petrosal extends narrowly along the upper side of the squamosal, and more narrowly below it, thus inclosing in a long, conical cavity the inner process of the squamosal.

Are not these relations of the *squamosal*, wedged in between the petrosal and the exo-paroccipital, anomalous among reptilia?

Petrosal *(prootic).*

Platecarpus. The petrosal unites by a short, flattened, sutural surface with the exterior part of the basioccipital and by a longer, similar one, with the basisphenoid. The thickened anterior margin is emarginate near its middle for the trigeminal nerve, a protuberance superiorly sometimes partly inclosing the notch into a foramen. Just back of this emargination, on the inner side, is the opening for a small foramen. On the outer side, near the posterior margin, there is an elongated slit covered by a thin scale of bone, having a small foramen at its bottom The surface for union with the parietal is shorter than that for the supraoccipital, which it meets in nearly a right angle. The groove for the stapes is dilated somewhat beyond the foramen leading into the semicircular canals. These openings are chiefly excavated from the petrosals, with a smaller excavation upward into the supraoccipital and another into the exoccipital. The sutural surface for the parietal is flatly truncated, and was evidently covered with cartilage for union with the thin, decurved margin of the descending wing of the parietal. The anterior part of this surface, continuous with the anterior border as far as the trigeminal notch, is markedly roughened for ligamentous attachments. The petrosal in general is triradiate in form, of which the stouter branch is for articulation with the basioccipital and basisphenoid, the longest for union with the exoccipital, covering the process of the squamosal, as described in that bone. The smallest process is for the union with the supraoccipital and parietal. The external branch is flattened distally, lying upon and in front of the exoccipital and reaching nearly to its distal extremity. Rarely is the bone found sepa-

rated from the exoccipital. The bone articulates with the parietal, supraoccipital, exoccipital, basioccipital, basisphenoid, and squamosal.

Squamosal.

Clidastes. The squamosal is a small bone, firmly wedged in between the prosquamosal and paroccipital, as also the petrosal. It articulates broadly on the outer side with the prosquamosal, sending a more or less elongated process along the upper inner side of that bone, which may touch the posterior end of the postfrontal. A long, thinned and curved process is directed upwardly and inwardly to unite with the distal extremity of the parietal process, completing the parieto-squamosal arch. Internally it is broadly and firmly united with the exoccipital of Cope, the paroccipital of Baur, extending inward on the anterior face. In none of the specimens in the museum is the petrosal separated from the exoccipital, so that it cannot be said with certainty that the relations of the parts in this genus are like those of *Platecarpus*, but such is doubtless the case. Below, it forms the middle, antero-posterior, elongated portion of the quadrate articular surface, which is completed on the outer side by the prosquamosal, and, to a very slight extent, in some cases at least, by the paroccipital. The bone articulates with the paroccipital, petrosal, parietal, prosquamosal, and, in some cases to a limited extent, with the postfrontal.

In *Platecarpus* the squamosal closely resembles that of *Clidastes*. The internal process on the paroccipital extends very nearly to the semicircular canals, forming a long, slender, pyramidal process firmly wedged in between the exoparoccipital and the petrosal, and completely excluded by them from the external surface. The parietal branch is rather longer, and there is no process extending on the prosquamosal.

In *Tylosaurus* the internal process is probably like what it is in *Platecarpus*, but this cannot be determined. There is sometimes a slender process on the prosquamosal, as in *Clidastes*, though never reaching the postfrontal.

Prosquamosal ***(quadratojugal, squamosal).***

Clidastes. The prosquamosal is an elongate bone, dilated posteriorly. The posterior end is turned downward, with an excavation on the lower side for the outer part of the articulation for the quadrate bone. On the inner side distally it articulates with the squamosal, the anterior process of which extends forward as described below. The anterior end forms the inner and upper part of the arch, extending nearly to the anterior end of the arch, but not reaching the jugal. It is deeply grooved on the outer superior side for the postfrontal, which extends to a point nearly as far back as the surface of the quadrate. It articulates with the quadrate, squamosal, and postorbital.

Platecarpus. Pl. xxvi, f. 4. The prosquamosal differs from that of *Clidastes* in its relations to the squamosal. In *Clidastes* the upper border of the posterior end is convex and scarcely elevated above the body of the bone, or, if so, only slightly. In *Platecarpus* there is a flat process on the upper part, uniting with the squamosal, which does not send a process forward. The bone anteriorly reaches as far forward as the jugal process of the postorbital, and touches the jugal.

Tylosaurus. The prosquamosal in this genus articulates with the jugal, as in *Platecarpus.* It differs from *Platecarpus* in the more rounded, wing-like process on the upper side distally, which is pointed in the former and scarcely at all projecting in *Clidastes.* The bone, also, is more curved downward at the posterior end in this genus.

Ectopterygoid *(*or ***transverse bone).***

The ectopterygoid has never been found in *Clidastes,* and in all probability it is very incompletely ossified in this genus, since the slender jugal shows only a small articular surface for it, or none at all.

In *Platecarpus* (pl. xxv, ff. 4, 5) the bone varies considerably in shape in different individuals, the jugal branch being longer or shorter. It is somewhat L-shaped, with the shorter branch

broad, and with an oblique sutural surface on the under side for union with the expanded end of the ectopterygoid process of the pterygoid. The anterior branch is slender and more or less pointed. Its outer surface is flattened and roughened for sutural union with the jugal. It does not reach to the maxilla.

In *Tylosaurus* the bone differs only in being a little more slender; the pterygoid end less broad. It articulates with the jugal in same way as in *Platecarpus*, not reaching the maxilla.

Quadrate.

Clidastes. Pl. XXIV, f. 7. From below, the articulation of the quadrate is a little longer from side to side than antero-posteriorly. In the former direction it is somewhat concave, with a median convexity. From without, the rim of the ear cavity forms a nearly complete circle, the diameter a little greater from above downward, and extending to the tip of the suprastapedial process. Its lower margin terminates in a small, roughened process, nearly opposite the tip of the suprastapedial process, but external to it, and the articular surface of the lower end of the bone is beveled so that its upper margin nearly coincides with the lower border of the ear cavity. At the upper extremity the articular surface is convex in both directions, more strongly so antero-posteriorly. Anteriorly the articular surface divides into two processes, of which that on the upper border of the ala, the alar process, is the longer and narrower. Back of the junction, the sides of the surface are nearly parallel to opposite the top of the auditory notch, where it is narrowed at the expense of the outer side, which is depressed and roughened. The suprastapedial process is directed downward and somewhat inward, reaching a little below the middle of the bone. On the inner side the suprastapedial process is excavated above, and toward the tip there is a smooth, oval, articular surface looking inward. The inner border is nearly straight from above downward, with a raised, narrow ridge beginning below the meatal pit and continuing nearly to the inferior extremity. In front and slightly below the pit there is a distinct roughening on the convex border. The roughened projection on the posterior side below is

confined to the outer side at the extremity of the alar ridge, the surface at its inner side being smoothly convex. The superior surface has the internal process much elongated and narrow, the cavity between it and the alar process deep.

There are two, perhaps more, distinct types of quadrates in the genus *Clidastes*, corresponding to the emarginate and non-emarginate coracoid. To the first type belongs *C. velox*, and *C. pumilus*, if it be distinct; while in the second are included *C. tortor*, *C. propython*, *C. dispar*, *C. westii*, and probably all the others now known. All of these last-mentioned species have quadrates so nearly alike that they do not offer trustworthy specific differences. Differences there are among them, but it is yet to be determined whether any of them are of more than individual importance. The accidental distortions to which the Kansas specimens are liable render it hard to determine which are adventitious and which are structural. The quadrate of *C. tortor* differs from that of *C. velox* as follows: The internal border between the superior and inferior angles is deeply concave, instead of being nearly straight. The border is smooth and rounded in the concavity, and is more or less sinuous. In *C. velox*, it is nearly straight, and has a distinct rugosity just in front of the meatal pit, and a distinct ridge below it, both of which are wanting in *C. tortor*. The articular surface of the suprastapedial process is more narrowed on the upper part, the lower end more dilated. Below the end of the process, near the inner side, there is a more or less strong tubercular rugosity, wanting in *C. velox*, where the rugosity is toward the posterior side, and is represented by a strong rugose ridge in *C. tortor*, extending from the tubercular rugosity obliquely to the outer inferior angle. The posterior surface is nearly plane from side to side, and convex from above downward to near the lower part. In *C. velox* there is a deep and broad channel, and the surface is strongly concave from side to side as well as longitudinally. The ala is somewhat less dilated and more elongated vertically. The upper articular surface is much more deeply concave between the anterior and alar processes in *C. velox*, while the inner border at the base of the suprastapedial process

is much more concave in *C. tortor*. The inferior surface appears to be broader from side to side in *C. tortor*.

Quadrate No. 1119 (pl. LXIV, f. 4) is in a measure intermediate between that of *C. tortor* and *C. velox*. The internal posterior rugosity is smaller, the anterior border above more concave, and the anterior surface somewhat channeled. The quadrate of *C. westii* closely resembles that of *C. tortor*.

The quadrate of *Mosasaurus horridus* agrees best with that of *C. tortor*, though very different. The interior border from above downward is slightly convex in the middle, projecting beyond the plane of the ends, instead of being concave. The infrastapedial rugosity is very much larger than in *C. tortor*, and situated higher up. Between it and the anterior border there is a strong channel, terminating near the thin inferior border of the stapedial pit. The ridge limiting the inferior border of the ear cavity posteriorly is sharper, though less prominent. The suprastapedial process is much shorter, terminating almost exactly opposite the middle of the bone. It is much broadened below from side to side. The superior inner process of the articular surface is very short and obtuse, with only a short concavity between it and the alar process. The anterior surface is nearly straight from side to side in the middle and only moderately convex longitudinally. The stapedial pit is of large size, oval and vertial, its upper end reaching only a little above the upper end of the meatal notch. The inferior articular surface is much elongated from side to side and only a little broader on the outer part. In *Clidastes* its breadth is much greater on the outer part.

The quadrate of *Brachysaurus* (pl. XLVI, f. 2) is, in several respects, very remarkable. Its inner side from above downward is very deeply concave, the border sinuous. The border to above the middle is thin and sharp, the face including a deep channel that terminates on the anterior side of the meatus. On the upper part, as the deep channel turns backward to the opening, the border is broader, but limited posteriorly by a rather sharp edge that runs to the inferior part of the stapedial

pit. The stapedial pit is situated very high up, almost wholly above the meatus, and is more rounded. Its lower border behind is low and thin, and forms at the same time the upper margin of the meatal orifice. The suprastapedial process is very stout and broad, descending a little below the middle, and broadly and firmly coossified below with the very large and stout process. Its inner side is excavated and roughened, with a sharp, thin ridge separating it from the meatus. The posterior surface is moderately channeled from side to side in the middle, more deeply so above. The ala seems to have been only moderately broad. Externally the ear cavity is very deep and small, ending in the very large opening inclosed by the suprastapedial process and the tubercle below. The vertical diameter of the rim is only a little greater than the transverse one, and is distinctly less than half the height of the bone, the floor being more nearly horizontal, and not extending nearly so far toward the inferior angle as in all the other quadrates described in the present work. The superior articular surface has a broad and prominent anterior process, with a long concavity between it and the alar process, and a broad upper surface of the suprastapedial process, which, however, is placed for the most part very obliquely. The outer side, below the ear cavity, is very broad and rugose. The lower articular surface is elongated from side to side, and moderately dilated externally.

Platecarpus. Pls. LX, LXI. The quadrate of *Platecarpus* differs very markedly from that of *Clidastes* in the greatly elongated suprastapedial process. On the inner side, the large, oval, stapedial pit is situated higher up. It is larger and more oval, situated nearly as in *Brachysaurus;* that is, with its long axis very oblique, its thin posterior border forming the upper margin of the meatal opening. The prominent internal border is formed of a broadly rounded ridge, slightly convex longitudinally, ending below in the flattened inner surface of the articulation for the pterygoid. Between this ridge and the inferior rugosity there is a shallow pit or channel, very much as in *Mosasaurus*. The internal angle above is much less prominent than

in *Clidastes*. The inferior anterior angle is acute and the border for a short distance is thin and sharp. The anterior surface is only moderately convex longitudinally, but has a distinct channel, concave from side to side. The alar process of the upper articular surface is not as long or slender as in *Clidastes;* that for the suprastapedial process broad and not constricted. This process is long, reaching much below the middle of the bone, and arches far backward. It is stout, only a little expanded distally, and incloses a large, broad notch between it and the body. Its inner side above is beveled or excavated much as in *Brachysaurus*, leaving a free rounded border next the opening. About midway in the process there is a rather large, rounded, smooth articular surface on the inner side, posteriorly. The ala is very large, broad, and thin. Its border is continuous from the end of the suprastapedial process to the rugosity below the process, and is everywhere thin and prominent, and nearly all on one plane. At the lower part, there is a much deeper concavity than in the other forms, behind and above the very prominent ridge or plate that continues the border to the rugosity. This rugosity is in the shape of a small tubercle. The inferior articular surface is small — very small in proportion to the size of the bone — and has a prominent articular projection in the middle in front. The bone is very large in proportion to the size of the skull, as compared with that of the other genera.

Tylosaurus. Pls. LX, LXI. As is the case with *Clidastes* and *Platecarpus*, the quadrate of *Tylosaurus* is very characteristic of the genus, resembling, however, that of *Clidastes* more than that of *Platecarpus*. Anteriorly the shape is much like that of *C. tortor*, the inner margin less concave, the outer less convex, the shape being more like that of a parallelogram, with the two articular ends beveled outwardly. The surface is less convex from above downward, and there is a distinct longitudinal channel, the surface transversly in the middle not being plane as in *C. tortor*. The internal face is much like that of *C. tortor*, the concavity and sinuosity less. The stapedial pit is moderately oblique and extends for about half its length

above the upper end of the meatal notch. The suprastapedial process is very short and broad, and its posterior face only a little constricted above. It extends only about a third of the length of the bone. On the posterior surface there is a strong rugosity a little below the middle of the bone, continued into an oblique low ridge that runs to the outer inferior angle. The ear cavity is more shallow and much longer from above downward than from side to side; the outer border but little convex. Its wall is thicker than in *Platecarpus*, where the bottom of the concavity is very thin. The inner angle above is stout and much produced, but the concavity between it and the alar process is long and not very deep. The inner border of the articular surface is rather deeply concave.

Mandible. (Pls. XXII, XXII.)

The mandible is one of the most peculiar parts of the Mosasaurian skull. It is proportionally very large and stout, and exceeds the skull proper in length. Back of the middle there is an imperfect joint between the splenial and presplenial bones. This joint admitted motion in both lateral and vertical directions, though chiefly in the former. The motion, even laterally, could not have been great, since a thin plate of the angular extends forward within the cavity of the presplenial. Doubtless this thin extension was elastic, permitting some inward flexion of the dentary, and helping to restore extension. The extension of the articular back of the cotylar cavity was never great, but the broad, stout posterior part of the mandible evidently indicated powerful muscles for the seizure and holding of the prey. The following descriptions of the different elements is from a jaw of *Platecarpus coryphæus*, a figure of which from the inner side is given in plate XXII.

The *articular* forms part of the cotylar cavity — a little less than half — the sutural line running obliquely from before backwards and outwards. The surface in this part is concave from side to side. The portion back of the cavity, separated by an obtuse ridge, is placed obliquely, though in most specimens it is crushed flat so as to lie vertically, while in reality it is more

nearly horizontal at the extremity. Its upper margin is convex, running to the obtuse inferior angle. This much of the bone is the chondrogenous element of the Testudinata and Rhynchocephalia known as the articular. The anterior portion, according to Baur, is the co-ossified angular. "What is the articular of the Lacertilia? A consideration of its relations to the other elements of the mandible teaches that it is nothing else than the chondrogenous articular plus the dermogenous angular of the Testudinata and Rhynchocephalia. The so-called angular of the lacertilians is the splenial, and the so-called splenial is the presplenial of the Chelyoidea."[54] If these conclusions are correct, it becomes necessary to revise our nomenclature of the elements of the lacertilian mandible. That the nomenclature here used may be readily homologized with that hitherto used I give the correlative terms, as follows:

Articular	Articular plus angular (articulo-angular).
Angular	Splenial.
Surangular	Supraangular.
Coronoid	Complementary.
Splenial	Prespenial.
Dentary	Dentary.

That portion of the bone that would be the angular of Baur shows no separation whatever in any of the forms from the articular proper. The suture separating it externally from the surangular proximally and splenial distally runs obliquely downward from the posterior part of the cotylus, and then nearly parallel with the lower border of the bone. Internally it forms a long, thin tongue, extending forward beyond the articulation, to be inclosed within a cavity of the presplenial. It is very thin where it crosses the articulation, but is here undoubtedly capable of bending; otherwise the joint between the two segments of the jaw would be immovable. Below on the inner side, the anterior projection, the angular proper, is slightly overlapped by the margin of the splenial. Above, it meets the ridge-like convexity of the surangular below the coronoid, inclosing between it and the surangular a long, flattened cavity.

54 Anatom. Anzeiger, XI, p. 412, 1895.

Just below the proximal end of the coronoid an elongated foramen leads into the upper part of this cavity.

The surangular forms the outer anterior three-fifths of the cotylus, the surface strongly concave antero-posteriorly, gently convex from side to side. Posteriorly on the outer side, the bone unites obliquely with the articular, and from back of the middle with the splenial, which forms the inferior border of the mandible here. The upper border, as far as the coronoid, is thin and sinuous. The extremity is broad and oblique, fimbriated or roughened. On the anterior half, the lower border is narrowly and deeply grooved for the reception of a tongue from the splenial. Posteriorly and internally to this groove, there is another for the reception of the margin of the articular. On the inner surface, below, the bone is excavated for the reception of the flattened part of the articular, its upper margin being an angular margin or ridge reaching about midway. Above this process a groove leads down into an excavation, which is broader in front, forming a foramen leading into the cavity between the articular and surangular. The upper border in front is thickened and rounded for the reception of the coronoid, with a sharp, thin, sinuous margin on the outer side posteriorly. Just below the surface for the coronoid near the anterior margin, there is a groove leading into a foramen. The lower margin of the bone is suturally united with the splenial and the angular, as already described.

The *splenial* of Baur, the angular of authors, forms the thickened and rounded lower border of the bone for more than half the distance back of the articulation. At its distal extremity it has an oval, vertical, articular surface, convex in both directions, for union with the presplenial. The bone is U-shaped in cross-section, the outer lip with a narrow tongue for insertion into the surangular, the inner one thin and overlapping the angular, but not reaching to the coronoid. In the cavity between the two the plate-like process of the articular is received. See plate LXIII.

The *coronoid* has its upper border deeply concave antero-posteriorly, convex and rounded from side to side. It is U-shaped

in section. Posteriorly on the outer side it has a free curved margin, inclosing a groove or fossa, which is narrowed and shallow below, deeper and broader above, and which looks downwards, outwards, and backwards. Its upper border is thinned, roughened, and irregularly U-shaped. The anterior end of the bone is irregularly roughened.

The *presplenial* lies on the inner inferior side of the dentary, extending as far forward as the fourth tooth. It appears on the outer side at the inferior posterior part, where it is stout and rounded on the lower margin. For a large part of its extent it forms a deep groove or channel; that is, it is somewhat U-shaped in section, with the inner side longer and each with a thin margin. At the posterior extremity the large articular surface for union with the splenial is placed at right angles to the long axis of the bone. It is rather deeply cupped, oval or subcrescentic in outline, with the long diameter vertical. Anteriorly the bone is thin, covering up the narrow, deep groove for Meckel's cartilage.

The *dentary* comprises more than one-half of the entire length of the mandible. It is widened gradually behind, the upper border straight or gently concave, the lower border somewhat convex. Anteriorly it projects a short distance beyond the first tooth, ending obtusely. On the inner side in this region the groove for Meckel's cartilage begins a little distance before the first tooth, the surface below flattened as far back as the second for apposition with its mate. There are eleven teeth in the dentary of this species, with eight or ten foramina in a row below them exteriorly. Posteriorly the jaw projects a short distance back of the last tooth, ending in a short, striated process. From without, the jaw in front of the articulation is composed almost wholly of the dentary, the presplenial showing only at the posterior and lower part, the separating suture appearing nearly opposite the fourth tooth from the end and running back nearly parallel with the upper border. On the inner side the presplenial reaches to in front of the middle of the bone, opposite the fourth tooth. In front of this bone the groove is partially closed by its thin margins. The articulation back of

since there is no sacrum in these animals. I know of no reptile, as I have previously stated, in which this arrangement of the non-costiferous vertebræ is not the rule, and it seems strange that the error of confounding the non-costiferous and non-chevron-bearing vertebræ with the mammalian lumbar vertebræ should have persisted so long. In the Mosasauria there is never a sacrum; the rod-like ilia are directed, not backward, but forward, ending without attachment, but doubtless lying in contiguity with the most anterior of the pygals. The symphysis of the ischia is thus thrown below the fourth or fifth vertebra succeeding. If these vertebræ bore chevrons it will be immediately seen they would have protruded into the pelvic cavity, obstructing the outlet. Not less than five or six pygial vertebræ are necessary in these marine lizards to leave space for the free exit of the cloaca.

The relative lengths of the thorax and tail vary in the different genera. While in *Clidastes velox* there are as many as forty-two precaudal vertebræ, in *Tylosaurus* and *Platecarpus* there are not more than thirty, with seventy-seven caudal vertebræ in the first and eighty-six or more in the last two.

Atlas.

Clidastes velox. The intercentrum is a small bone with its three principal sides of nearly equal extent; the two upper articular surfaces are gently concave, and meet in a transverse obtuse border. The anterior margin is thin and sharp, the articular surface behind it for the condyle more concave than that for the odontoid. The inferior surface is convex, both antero-posteriorly and from side to side, with a roughened longitudinal prominence in the middle on the posterior part for muscular insertion. The posterior articular surface is limited by a narrow groove below on the margin of the bone. The bone articulates broadly behind with the atlantar hypapophysis, reaching above to the surface for the odontoid, and, on the ends, to those for the lateral pieces. The lateral pieces have distinctly separated articular surfaces for union with the condyle, intercentrum, odontoid, and axis. The facet for the intercentrum

at the inferior part of the bone is smallest, looking nearly inwards. That for the condyle is flattened, looks nearly forward, and is vertical in position. The superior facet, oblique in position vertically and transversely, is for union with the axis, and is more or less confluent with the internal triangular surface for the odontoid. On the outer side the bone is strongly convex from above downward, with a flattened process on the posterior upper part, directed upwards and forwards, and expanded obliquely at its distal extremity. The inner side of the top margin is beveled and striated, and is probably contiguous or approximated with its fellow of the opposite side. Directed downwards and backwards from the posterior inferior side, there is a stout styliform process. Above it there is a small tubercular process on the posterior margin of the upper process, directed backward.

In *Platecarpus* and *Tylosaurus* the intercentrum resembles the same bone in *Clidastes*, being a little broader antero-posteriorly. The lateral processes have the upper process somewhat broader, and the styliform process is very much shorter.

Axis.

Clidastes velox. The neural spine of the axis is elongated antero-posteriorly, its length above equal to that of its proper centrum. It is thin on the anterior portion, the border sloping upward, the posterior border thickened, stout, and oblique in position. The transverse processes are flattened and horizontal, the smallest of the costiferous series, and with only a small articular facet for the rib. The stout postzygapophyses have their faces looking obliquely ventrad and laterad. The zygosphenal articular surfaces are wholly wanting on the inner side of the triangular cavity between the borders leading to the two articulations. The articular surface of the centrum behind is smoothly convex, a little broader from side to side than from above downward, and only faintly emarginate above. The hypapophysis is the largest of the series, and is suturally united with the stout exogenous process of the centrum, which is directed almost directly ventrad, its posterior margin close to the articular bor-

der. The hypapophysis is directed obliquely backward. The atlantar hypapophysis forms the cephalo-ventral part of the centrum, articulating anteriorly with the intercentrum of the atlas, and above suturally with the axis. It bears on its inferior surface a small process directed caudad and ventrad. Between this process and the anterior border of the exogenous projection of the centrum behind there is a deep emargination, the two hyapophyses being separated by a considerable interval. The odontoid process is united to the body of the axis by suture. Its upper surface is nearly horizontal and shallowly concave. The articular surface for lateral pieces and the occipital condyle is oblique and slightly concave from above downward, the upper margin rounded and semicircular from side to side.

The axis in *Platecarpus* differs from that of *Clidastes* in the spine being more prominent in front, in being thicker behind, and in the ball being not at all emarginate above. The hypapophysial protuberance is shorter or nearly sessile. The postzygapophyses stand out more freely, the ridges above them are less prominent. The hypapophysis is entirely free.

Third to Seventh Cervical Vertebræ.

Clidastes velox. The third cervical vertebra shows a well-developed zygosphenal articulation posteriorly. The transverse processes are small, only a little larger than those of the axis, but, unlike them, they are strengthened by a ridge running obliquely ventrad and caudad from the under side of the anterior zygapophyses. The hypapophysial projection is rather longer and stouter than that of the axis, the hypapophysis itself of about the same size, or a little smaller, and directed, like that, backward. The spine is a stout rounded, or trihedral projection, with a sharp carina on the anterior side, less oblique on its margin. The spine is directed rather more obliquely than in the following vertebræ.

The fourth cervical vertebra has stouter transverse processes, the anterior portion, turned downwards and then forwards to the rim of the cup, is stronger, the oblique ridge leading to the under side of the zygapophyses stouter, and the hypapophysis

is directed rather more directly ventrad. The spine is less stout than in the preceding, and is rather more vertical in position and the anterior thinned part above is more dilated.

The fifth cervical vertebra differs from the fourth in the broader spine, the stouter transverse processes, and the smaller hypapophysis.

In the the sixth cervical vertebra the hypapophysis is reduced to a small ossification in some cases, always distinctly smaller than that of the preceding vertebra, and it is directed wholly ventrad. The spine has reached nearly the full width of that of the following vertebræ, though it is somewhat stouter above. The transverse processes are yet stouter.

In the seventh or last cervical vertebra the hypapophysis is wanting, or is the merest rudiment. The hypapophysial projection of the centrum is reduced in size, and the centrum in front of it has gradually assumed the shape of an obtuse carina.

Dorsal Vertebræ.

In *Clidastes velox* there are thirty-five vertebræ between the last cervical and the first non-costiferous vertebra, to which the pelvis was, evidently, related. The distinction between the cervicals and thoracics cannot be made out from any inherent character, as the last cervical does not bear a distinct hypapophysis. In a series of vertebræ referred to *C. pumilus*, a species doubtfully distinct from *C. velox*, the seventh vertebra bears a short rib. In a specimen of *C. velox* the eighth post-cranial vertebra has a long rib attached to it, evidently articulating with the sternum. From this it is evident that there are seven true cervicals. Posteriorly, also, there is no distinction between the thoracic vertebræ and those of the lumbar region. All the vertebræ anterior to the pelvic region bear ribs, and all should be considered as dorsal vertebræ, the true thoracic vertebræ being restricted to those in which the ribs are elongated and inclosing the thoracic cavity, whether connected with a sternum or not. In the anterior dorsal vertebræ the centra are subcarinate below, the obtuse, rounded keel becoming less and less apparent until no

indications of it can be seen, before the middle of the series. The transverse processes reach their maximum in the first thoracic vertebra. On the anterior cervicals, the articular surface is nearly rectangular and the two arms of nearly equal length, the anterior one reaching nearly to the rim of the cup, the other thicker, vertical and uniting near its upper end with the stout, rounded ridge from the anterior zygapophysis. In the posterior cervicals the anterior arm assumes a more oblique position, the included angle being more obtuse; it is shorter and does not reach as near to the rim of the cup. In the first thoracic the vertical branch is nearly twice the length of the other. In the third or fourth the anterior arm has become a short, curved, pointed projection, directed more downwards than forwards. The upper posterior angle is curved backward in the whole series to a moderate extent, giving, in the anterior dorsals a curved articular surface resembling the italic letter *S*. The zygapophyses have nearly the same position throughout. They are much the stoutest and the longest in the cervical and anterior dorsal region, showing evidently a greater range of downward curvature in this region. They immediately become shorter, and the oblique ridge connecting them with the upper part of the transverse process is weaker and more slender.

In the most anterior thoracic vertebræ the plane of the articular surface for the transverse process lies only a little exterior to the outer border of the zygapophyses, but posteriorly the process stands widely beyond the zygapophyses, being absolutely and relatively longer, and the transverse process is somewhat constricted before the end. The spinous processes increase very slightly in length and breadth, and are only slightly and nearly uniformly oblique throughout. The centra increase very slightly in length to beyond the middle of the series, the posterior ones being distinctly more slender, and, as already stated, have more protuberant transverse processes. The vertical diameter of the ball increases slightly, while the transverse diameter remains more nearly the same.

Caudal Vertebræ.

Immediately following the thirty-fifth costiferous vertebra in *Clidastes*, the tubercular rib-process gives place to an elongated non-costiferous process. There are seven such vertebræ in this species — with elongated flattened process and without chevrons. A distinctive name for them is needed, and in a previous paper[55] the name *pygial* was proposed. These pygial vertebræ, or pygals, are seven in number in this species. The under surface is somewhat flattened, and, as in the preceding vertebræ, is gently concave antero-posteriorly. The transverse processes are elongate, flattened, with a thin rounded extremity, and are directed gently downward. In the anterior vertebræ the processes spring from the anterior part. As the centra become shorter they arise from near the middle. In the last of the series there are minute indications of chevrons. The centra, which had already begun to decrease in length in the posterior part of the lumbo-dorsal series, diminish rapidly, the last being only three-fourths the length of the first. The transverse processes are of nearly the same length throughout, their expanse being fully four times the length of the first centrum.

The centra of those vertebræ which bear chevrons do not differ much in shape. They become less constricted, and, back of the middle of the series, are smoothly cylindrical in shape. The transverse processes decrease gradually in length and size, and ascend somewhat on the centrum, disappearing entirely on the twenty-fifth or twenty-sixth. The spinous processes are now much narrower than in the precaudal series, though of nearly the same length, increasing gradually in this respect for the first twenty of the series, and are markedly oblique, with the posterior border stout, and the anterior border alate. With the twenty-sixth, where the transverse processes cease, the spines begin to increase rapidly in length, and have become more vertical in position, with both borders thinner. In the thirty-fifth or thirty-sixth they attain their greatest length, and are here directed slightly forward. Thence to the end of the tail the spines decrease gradually and they become more and more oblique

55 Kansas Univ. Quart., I, 22.

backward. Towards the end of the tail, the length of the centra decreases more rapidly than in the anterior parts, finally terminating in a mere nodule of bone. In the well-preserved specimen described there are seventy-seven vertebræ with chevrons, all continuous, except in one place. The last one is less than a fourth of an inch in diameter, and shows that there had been yet another, possibly several more. The entire series was not less than seventy-eight and probably not more than eighty. The chevrons are strongly oblique throughout, and are firmly coossified with the centra. They are much more slender and longer than in the other genera.

The tail of *Clidastes*, as is thus seen, has a broad, vertical, fin-like extremity, and doubtless aided very materially in the propulsion of the animal through the water.

In *Platecarpus* the cervicals are less slender than in *Clidastes*. There are no zygosphenes, or the merest rudiments of them; the centrum is more transverse. The centra are transversely oval in the dorsal region, more pear-shaped in the pygal, and vertically oval in the caudal. There are six pygals, and their transverse processes are stouter and flatter than in either of the other genera. The vertebræ bearing transverse processes behind the pygals are fewer in number than in either of the other genera. The precise number of the vertebræ bearing chevrons cannot be determined, though in all probability the tail does not differ in this respect from that of *Tylosaurus*. The spines are all regular, there being no dilatation of the tail as in *Clidastes*, and the obliquity is apparently also not irregular. The chevrons are longer than in *Tylosaurus*, but not nearly so slender and elongate as in *Clidastes*. They are all articulated by a rounded head into a small cup-like depression on the under side of the centra back of their middle.

In *Tylosaurus* the dorsal vertebræ are yet more transverse in outline and the pygals more pyriform. In fact, in most specimens of the pygals the centrum is found almost triangular in shape, the exaggerations due to the crushing, which almost always occurs from above downwards in these specimens, owing to the transverse processes fixing the position of the vertebræ

in the sediment. The caudal vertebræ are distinctly vertical oval. The spines and chevrons are stouter and shorter in proportion to the centra than in *Platecarpus*. The former, also, show a marked degree of irregularity in their obliquity, as will be seen in the restoration of this species. Probably this irregularity is not constant in all the different individuals of the same species. The number of the pygals is somewhat indefinite. In a specimen in the museum in which the vertebral column is complete there are five typical ones and two more with rudimentary tubercles for the chevrons. In others these tubercles are somewhat larger. The number is not less than five, and may be seven.

Below is given a comparison of the different regions of the vertebral column in the three typical species that have been discussed in this work.

Number of vertebræ.

	Clidastes.	Platecarpus.	Tylosaurus.
Cervical	7	7	7
Dorsals	35	22	23
Pygals	7	5	6
Chevron caudals	70	80?	80
	118	115?	116

Lengths of the different regions.

	Clidastes.	Platecarpus.	Tylosaurus.
Skull	0.420	0.512	0.816
Neck	.226	.240	.360
Trunk	1.360	1.345	2.000
Tail	1.460	2.160?	3.165
	3.466	4.257	6.341

Proportionate lengths of the different regions of the body.

	Clidastes.	Platecarpus.	Tylosaurus.
Skull	12.1	12.0	13.0
Neck	6.5	5.6	5.6
Trunk	39.2	31.3	31.5
Tail	42.2	50.7?	49.9
	100.0	100.0	100.0

Extremities.

In all the known Mosasaurs there are four functional limbs, varying not a little in the different genera in size and structure. The arm and leg bones are short and broad, the articular sur-

faces not conspicuously differentiated, and evidently capable of great dorso-ventral flexibility. The carpus and tarsus in some forms are well developed, with closely interlocking bones; in others the number may be decreased to a single one, a mere nodule set in a broad plate of fibro-cartilage. The metapodials cannot, in many instances, be distinguished from the phalanges, save by their greater size. They are all elongated, hour-glass shaped, somewhat flattened at either extremity, and constricted into a cylindrical or flattened shaft. In *Tylosaurus*, the thin membrane supporting the digits has been found quite to the extremity and there can be no question but that the digits in all were webbed throughout.

Scapula.

Clidastes velox. The scapula is a thin flattened bone, with the lower portion thickened and stout. Its superior border is long and thin, somewhat thicker on the posterior half. The margin is squarely truncated for the attachment of a plate of cartilage, which extends up on the sides of the thorax, as in recent lizards. This cartilage is often preserved in a semiossified condition. The convexity is greatest near the middle of the superior border and near the anterior end — the margins more nearly straight between these points. Posteriorly the angle is acute, whence the posterior border, reaching nearly midway to the glenoid articulation, is straight, thinned, and nearly vertical, ending in a thin angle. Below this angle the border is concave, rounded and thickened below. The anterior inferior angle is nearly rectangular, the border below in front of the coracoid thin and sharp and concave, ending in a thickened, triangular, much-roughened process, just in front of the coracoid union, looking downward, for ligamentous attachment. The head of the bone is divided by an oblique ridge into unequal facets, meeting each other in an obtuse angle. The anterior one, the larger, is roughened for union with the coracoid. The posterior one is smooth, concave in front, convex behind, looking downward, backward, and outward. The outer surface of the bone is nearly flat, the inner more concave, the head being formed chiefly at the expense of this side. The glenoid

margin on the outer side is produced into a sharp, prominent lip.

Mosasaurus horridus. An imperfect scapula of this species apparently closely resembles the same bone in *Clidastes.* It is less distorted and crushed, so that the neck is less flattened, and the lip of the glenoid articulation is produced into a sharp, prominent ridge.

Platecarpus coryphæus. The scapula in *Platecarpus* has greater vertical height than in *Clidastes* and less antero-posterior elongation. The superior border is much more strongly convex, the greatest convexity being at the uppermost part. The posterior part is not as strongly produced, the angle not as acute. The free, thin upper border is much shorter or reduced to a short convexity, the concave border below it much longer and thicker. The anterior inferior border is concave as in *Clidastes,* ending in a sharp margin somewhat deflected on the inner side, the thinning due to a broad groove on the outer surface. In some specimens the border is concave, in others straight from the anterior angle to the smaller roughening in front of the coracoid articulation. Around the lip of the coracoid articulation there is a considerable ligamentous roughening, as in *Clidastes.*

Tylosaurus dyspelor. The scapula of *Tylosaurus* closely resembles that of *Platecarpus,* but is, relatively, both to the size of the coracoid and to the skeleton, a much smaller bone, its size in *T. proriger,* of twenty-four feet in length, being absolutely smaller than in *P. coryphaeus,* of thirteen feet in length. The bone in *Tylosaurus* is less expanded vertically and antero-posteriorly than in *Platecarpus.* The posterior emargination is shorter, the superior border thicker.

Coracoid.

Clidastes velox. The coracoid is a broad, thin, fan-shaped bone, flattened on the exterior surface, concave on the inner. The head, like that of the scapula, is divided by an oblique ridge into unequal facets, meeting in an obtuse angle. The anterior and large one for the scapula is concave, and directed ob-

liquely inwards. The outer posterior one, forming about one-half of the glenoid fossa, is largely concave, and is produced into a prominent ridge outwardly. The posterior inferior border is thickened, concave, and roughened immediately back of the glenoid margin, straight and thin distally, ending in a rounded angle. The anterior superior border is nearly straight or gently convex on the outer three-fifths, moderately thickened and ending in a rectangle. Proximally it is beveled convexly at the expense of the outer surface, terminating in a thin, sharp, prominent ridge, extending from the apex of the roughened triangular space in front of the scapular surface to the inner side of the superior border, a little before the middle. The inferior border is thin and convex throughout from before back, the convexity being greater on the posterior part. The border is lipped for cartilage, and is a little thicker near the posterior end. Just back of the anterior fourth of the border there is a deep emargination, with very thin margins. In front of this emargination the border of the bone is thicker, especially on the posterior half, where the border is swollen. Just back of the emargination the border is also a little thickened. About midway between the bottom of the emargination and the margin of the scapular articulation the small coracoid foramen pierces the bone from above downwards.

In most specimens of Mosasaurs from Kansas the bones are flattened, from pressure. The present specimen has, however, the two bones but little changed, so that the angle between the scapula and the coracoid is shown nearly as in life. Their relationship will be clearly seen in plate XXXI, figure 6, which shows the two bones as articulated, from behind.

Platecarpus. The coracoid of *Platecarpus* resembles that of *Clidastes* rather closely. The bone is longer and less expanded distally, the neck longer and proportionally narrower, the posterior margin longer and concave throughout.

In *Tylosaurus*, the coracoid is very large in proportion to the scapula. The anterior border is nearly straight, the posterior concave, the inferior strongly convex. There is no emargination.

Humerus.

This bone is characterized by the absence of a distinct neck, by its constrictions and transverse dilatation distally. There appear to be two distinct types, characterized by the tuberosities of the distal end.

Mosasaurus horridus. The humerus in this species is a massive bone, agreeing best with the humerus of *Clidastes.* The greater diameter of the proximal articular surface is anteroposterior, instead of transverse. The slightly pitted, transversely gently concave surface is crescentric in outline, with the concavity facing the radial border. At the ulnar side proximally, there is a stout, massive tuberosity, directed upward and inward, and rising about an inch above the articular surface. It is subovate in cross-section, its end convex, and the surface cartilaginous. The stout pectoral ridge is scarcely differentiated from the body of the bone, being very broad. It is situated nearly in the middle of the bone, its proximal end forming the inferior end of the large crescent already described. The distal border has the broad, thickened surface for articulation with the radius placed obliquely, looking to the radial side and also dorsally. At its outer end there is a stout, styliform, flattened process directed outwards in the horizontal plane of the bone, its oval extremity showing a cartilaginous surface. The ulnar condylar process is stout and projects on the palmar side of the bone. Its distal surface looks inward and somewhat downward.

Clidastes velox. In this species the proximal end of the bone is transverse, but less regular in outline than in the following genera. The glenoid articular surface is situated near the middle transversely, its surface concave in both directions. The articular or cartilaginous surface is continuous to the inner angle of the bone. This portion of the bone, which in *Mosasaurus* is raised prominently into a tuberosity, is only a little prominent in *Clidastes,* forming the inner two-fifths of the margin of the bone, and ending in a thin border. Possibly in life the resemblance between the two genera in this part may have

been somewhat greater, but the differences are nevertheless very marked. On the distal border, the thickened, smooth and nearly flat articular border for the radius looks very obliquely outward, more so than in any other form; it meets the surface for the ulna in a rounded angle. At the proximal (outer) rounded margin of the articulation begins the prominent, styliform radial process, directed outward in the plane of the bone; it is flattened from above downward, and its tip was covered with cartilage. The ulnar condylar process is stout and thick, its surface subtriangular in outline, looking downwards, inwards and distad. The surface of the bone on the outer (radial) side is roughened. The free ulnar border of the bone is much longer than the radial, and more deeply concave. The radial border forms a short notch between the upper angle of the bone and the radial process. The pectoral process is more distinctly differentiated than in *Mosasaurus*, is situated nearer to the radial side of the bone, and has, at its upper part, a distinct cartilaginous surface, separated from that of the head of the bone and looking more downward. The dorsal surface of the bone is convex transversely, and gently concave along the middle longitudinally. A humerus of *Clidastes westii*, from the Fort Pierre, in the collection, has not been subjected to compression or distortion. The shapes of the two ends are shown in plate XXXIX. It is probable that these outlines represent the general *Clidastes* type.

Brachysaurus overtonii. The humerus of *Brachysaurus* differs markedly from that of all the other forms. It is stout and broad. Its proximal end is angulated near the middle, both sides sloping away from the angle, much as in *Tylosaurus*. The ulnar side is the longer and thinner of the two. The distal border is much elongated, and more convex from side to side than in the other genera. Its greater thickness is on the radial side, whence the border turns proximad to near the middle of the bone, leaving only a very short, moderately deep notch between it and the superior angle. There is no radial process. The ulnar side of the distal margin is considerably thickened as far as the place where it is reflected downward, where it is contin-

ued as a thin margin into the stout ulnar condyle, whose surface looks downwards and distad. The pectoral process is very small, is oblique in position, as in *Platecarpus*, and is situated close to the radial side of the bone; its ridge is thin. The dorsal surface is markedly concave from side to side; the palmar surface, flattened and concave. The specimen described, like that of *Mosasaurus* has not been subject to the compression so common among the Kansas specimens. Its resemblances are apparently greater to *Platecarpus*, though very different in the convexity and angularity of the proximal end. See plate LXII.

Platecarpus coryphæus. The humerus in this genus is the most expanded of any of the forms known to me, its width distally being nearly as great as the length. The proximal border is nearly straight, transversly or gently concave along the middle, the margins thinner and rounded. The distal border is much expanded and broadly convex, forming nearly the half of a circle. The thickened articular surface for the radius looks a little obliquely outward; proximad to the thickened portion the border forms a gently convex outline, its chord nearly parallel to the longitudinal axis of the bone; this portion is thinned and the surface covered with cartilage. In no other form, save *Brachysaurus*, is the structure similar here. The ulnar side is more expanded than the radial, its convex border nearly longitudinal. The surface here, however, is thickened to form the tuberosity, which looks downward. The tuberosity is not very stout, and is connected with the ulnar articular border by a thinner margin, which is not emarginated. Both the radial and ulnar borders of the bone are deeply emarginated, the bone being much constricted above the middle. The ulnar border is a little, though not much, longer than the radial. The pectoral process is situated more nearly in the middle of the bone than in any of the other forms. It is obliquely inclined toward the radial side, and compressed from side to side, the ridge blending with the surface a little below the middle of the bone. Its cartilaginous surfaces reaches through more than half of its extent, and is either entirely separated from the cartilaginous surface of the head or is only narrowly connected. The proc-

ess is gently inclined toward the radial side. On the dorsal surface, a little distad and laterad of the middle, there is a small roughening for muscular attachment. The same process seems to be apparent in most of the genera, and may be called the deltoid tubercle.

Tylosaurus proriger. The humerus of *Tylosaurus* is the most elongate and least expanded of any of the Kansas forms, and is relatively the smallest. Its proximal end, unlike that of the other genera, save *Brachysaurus*, is not transverse, but strongly angulated a little to one side of the middle, its thinned border sloping sharply away to meet the radial border in a rounded angle about opposite the proximal fourth of the bone. The ulnar side of the proximal border is moderately thinned and slopes gently, and is more expanded than the radial side. The distal border is much thicker on the radial side, the ulnar side being thinner and only moderately expanded. The radial angle is thin and very slightly produced; it has no projecting process. The ulnar angle, though more prominent, has no thickened process. The free radial border is long and gently concave between the proximal and distal rounded angles; that of the ulnar side is longer and deeper, but, like the other, is nearly uniform in curvature, much more so than in the other genera. The pectoral process is less projecting than in the other genera, its cartilaginous surface smaller and situated more nearly the proximal end. The rounded ridge which it forms is situated nearly in the longitudinal axis of the bone, and in line with the radial thickening of the distal end.

Radius.

Mosasaurus horridus. The radius in this species, as in all the other species of the group, is much the larger bone of the forearm. It is very stout at the proximal end, broadly expanded at the distal. In the single specimen of this species known to me the outer part of the bone is missing. The inner part differs from the corresponding bone of *Clidastes* in the distal angle being more produced.

Clidastes velox. In *Clidastes velox* the radius is almost fan-shaped. The proximal end is thickened, ovate in shape, the greater thickening on the outer side. The articular surface is smooth and gently concave for close union with the humerus. Beyond the head, at about the proximal third, the bone is much contracted, the width here being about one-third of that in its widest place. On the distal end the bone is much expanded, forming more than half of a circle, with the carpal articular border a chord. The outer margin is short and deep, the border thinned. The inner border is thicker and about a half longer than the outer, its distal end forming an acute angle with the inner end of the carpal surface. The carpal border forms more than a third of the distal periphery. It is thickened, concave and smooth on the surface, and placed very obliquely to the axis of the bone — about forty-five degrees. The remainder of the distal border is thin, and gives attachment to cartilage. I can give no rule by which the bones of the two sides may be distinguished, save perhaps that the thickening of the proximal end seems to be less uniform on the dorsal side, its greatest convexity in cross-section being on the outer side.

Platecarpus. In *Platecarpus* the shape of the radius is much more like that of *Clidastes* than of *Tylosaurus.* The bone is broader and flatter, the proximal portion less constricted, the distal border more uniformly a half circle — that is, the carpal border is not so distinctly a chord of a circle — and the curvature transversely is less strong. The articular part of the distal extremity is only a little thicker than the free cartilaginous border. The whole surface of the border is, moreover, coarsely roughened, showing an intervening attachment of fibro-cartilage.

Tylosaurus. The radius of *Tylosaurus,* like the other paddle bones of this genus, is elongate and narrow. The proximal end has an oval articular face at right angles to the long axis of the bone, for articulation with the humerus. The shaft is only moderately narrowed to near the middle of the bone. The distal extremity is about a half wider than the proximal. On its inner side it is thickened for more than half its width; the

outer part is thin and moderately concave, and reaches the full length of the bone, from the thickened proximal to the distal angle. The bone has no articulation distally, the single carpal bone being set in a plate of fibro-cartilage, which is attached to the roughened border of the forearm bones.

Ulna.

Mosasaurus horridus. The ulna in *Mosasaurus* is a less broad bone than is the radius, but is rather stouter in its proportions. The proximal end is stout, thick, transverse, and rectangular, the surface somewhat cupped and smooth; in outline subtriangular, with the inner angle produced more than the outer. The distal extremity is less expanded than the proximal, and shows three facets for close union with carpal bones, separated from each other by slight angles, that on the outer side the most angulated. The middle facet, the largest, is nearly transverse to the long axis of the bone. The inner border is thicker than the outer and more deeply concave, the greatest concavity a little beyond the middle of the bones; the border extends from the sharp angle of the carpal articulation to the slightly rounded angle of the humeral. On the inner side the border is shorter, thinner, and less deeply concave, extending from the angle for the surface of the sesamoid bone to the rounded, thinned, olecranon expansion on the inner side of the proximal end. The shaft of the bone is twisted somewhat, so that the inner border at the proximal end is turned downwards. The dorsal surface of the bone is markedly concave longitudinally and transversely throughout the most of its extent, the plane of the proximal end twisted dorsally on the inner side. On the palmar surface the bone is strongly convex transversely and but slightly concave from end to end.

Clidastes velox. The ulna in this species differs only in minor details from the same bone of *Mosasaurus horridus.* It is more slender and less stout, the proximal articulation is placed a little more obliquely to the long axis of the bone, the olecranon process is smaller, and the corresponding inner border longer. The distal articulation is more oblique outwardly and there are but

two facets for articulation with the carpal bones. The outer one is straight and cupped and reaches over nearly the whole extent of the distal surface, that for the pisiform inwardly being merely a notch-like opening between the ulna and the ulnare carpal.

Platecarpus coryphæus. The ulna of *Platecarpus* is more nearly like that of *Clidastes* than of *Tylosaurus*. Both the proximal and distal articular surfaces are placed more obliquely to the axis of the bone and the distal expansion is greater. The olecranon expansion is not rounded, but angulated, the roughened cartilaginous surface meeting the free border in a right angle. In *Mosasaurus* the cartilaginous surface extends out a moderate distance on the projection, but in *Clidastes* the expansion from the edge of the humeral articulation is rounded and smooth. The distal extremity shows a large, thickened, roughened border on the outer side for the carpal bone; the outer part thinner, less roughened, and meeting the free border in a right angle. The bone, as in *Clidastes*, is concave above transversely, convex below.

Tylosaurus proriger. The ulna in *Tylosaurus* is the most slender of the arm bones of any genus. Its proximal extremity is a little wider than the distal, and placed obliquely outwards to the axis of the bone. The distal extremity is transverse and but little expanded, its border gently convex. Both the inner and outer free borders are long and gently concave, the greatest narrowing of the bone occurring a little beyond the middle. The olecranon expansion is thin, its border gently convex. The bone is convex from side to side, both above and below.

Carpus.

The carpus in *Mosasaurus* and *Clidastes* is composed of seven bones, closely articulating, forming a firm and but slightly flexible wrist. In *Platecarpus* there are four bones, the inner part of the wrist, between the radius and the first and second metacarpals, remaining cartilaginous. In *Tylosaurus* the carpals exist as a mere rudiment in a single, rounded ossicle, situated at the inner end of the radius and surrounded on all sides by cartilage.

Mosasaurus horridus. There are four carpal bones in the proximal row, which may be designated the radiale, mediale, ulnare, and pisiform. The radiale is trapezoidal in shape, the inner end narrower than the outer. Its proximal articulation is the longest and thickest; it articulates closely with the radius, but does not extend quite to the inner end of the distal border of that bone. The distal border, nearly as long and thick, is straight and turned somewhat more outwards; it articulates with the broad first metacarpal. The outer, free border is rounded and thinner than any of the others. The inner border, less thick than the long borders, meets the distal border in a rounded rectangle, and articulates with the rounded bone of the second row. Between this and the upper border the margin is rounded, where it meets the mediale for a short distance. The mediale is the next in size of the carpal bones, but is thinner than either the radiale or ulnare. It has a free, thin, concave, proximal border, extending from the distal, opposing angles of the forearm bones. The distal border, nearly parallel with the chord of the free border, is for articulation with the middle bone of the second row. Its outer border has three articular surfaces in this species; the two proximal ones rounded and indistinctly separated, for articulation with radiale and radius; the distal one, as long as the other two together, is for articulation with the third of the distal row. On the ulnar side there are two articulations, the proximal one the thickest of all, but short, for union with the ulnar; the other, long one, for union with the ulnare. The ulnare is a stout, nearly square bone, nearly or quite as large as the mediale. Its outer border, for union with the thinned mediale, is abruptly thinned. Its proximal and distal borders are very thick; the former slightly convex from above downwards, the latter gently concave. The distal one is a little the longer, and articulates with the third distal carpal; the proximal with the ulna. The outer side is rounded and has two small articular facets, the proximal one, the larger, forming an entering angle with the ulna, for the pisiform; the distal, smaller one, for articulation with the fifth metacarpal. In the distal row there must have been three carpals, only one of which

is preserved in this specimen. The outer one is subround or subquadrate, and articulates with the following bones, there being no free border: radiale, mediale, medial distal carpal, first and second metacarpals.

Clidastes velox. The carpals of *Clidastes* are seven in number, situated in two rows, and firmly articulated with each other and the adjacent bones. They very much resemble the bones of *Mosasaurus*. The largest is the radiale, an irregularly shaped bone, and thicker than any of the others. Its thickest facet is for articulation with the radius. Its rounded outer angle is free. Its longest face, directed obliquely outward, is for articulation with the first metacarpal. On the inner side there are two facets, indistinctly separated, the proximal for articulation with the mediale, the more distal one for the outer distal carpal. Between the mediale and the angle of the radius there is a short, free, rounded border. The mediale is five-sided. Its shortest side articulates with the radiale; the longest, at the opposite end, with the ulnare. Between these faces distally there are three articular facets for the three distal carpals, the outer one the longest, and meeting the middle in an angle. Proximally, between the radial and ulnar facets, the border is free, concave, and thinned, continuing the curve from the radiale to the angle of the ulna, which the bone slightly touches. The ulnare is indistinctly five-sided, and is the second largest bone of the carpus. The largest and thickest face articulates with the ulna; the shorter face, on the outer side, with the mediale. Internally, the broad, rounded end has two facets, indistinctly separated, for articulation with the pisiform and the fifth metacarpal. The pisiform, an elongate bone, is inserted into the entering angle between the ulna and the ulnare; of the two proximal faces, that for the ulnare is a little the longer. The distal extremity is transversely convex, and is tipped with cartilage. The two sides are parallel and free, the distal one shorter and thinner than the proximal one. The distal carpals, three in number, are all of nearly the same size and shape, the inner one a little the largest. They are irregularly four- or five-sided. The inner one articulates with the ulnare, the mediale and the second dis-

tal carpal, and with the first and second distal carpals. The middle one articulates with the mediale, the other two of the distal row, and the third metacarpal. The outer one articulates with the radiale, the mediale, the middle distal carpal, and the fourth metacarpal. These three bones are thinner than the others, save the mediale.

Platecarpus. The carpal bones of *Platecarpus* are four in number, articulating rather closely together, and situated on the ulnar side of the wrist. They are the ulnare and mediale of the proximal row, the first and second of the distal row. The radiale, pisiform and outer distal carpal are wanting. This structure in connection with the absence of the condylar process of the distal extremity of the radius and the much weaker first digit, shows a decided inferiority in this part of the paddle as compared with *Mosasaurus* and *Clidastes.* The ulnare, the largest, articulates with the ulna, fifth metacarpal, and the other three carpals. The mediale articulates with the ulnare, radius, and outer distal carpal. The two distal carpals articulate with the second and third metacarpals respectively.

Tylosaurus. In *Tylosaurus* there is but a single carpal, a small, rounded bone, situated opposite the end of the ulna, and doubtless corresponding to the ulnare. It does not articulate with any bone, but was surrounded on all sides by cartilage.

Metacarpals.

Clidastes velox. Of the five metacarpals in *Clidastes*, the first is the broadest, the fifth the shortest, and both much flattened. The other three are more slender, with expanded extremities and constricted shaft. The first is much expanded on the proximal extremity, the broadly convex end articulating with the radiale, and, together with the next three, permitting very free lateral movement. The distal extremity is less expanded than the proximal, the end squarely truncate for close union with the phalanx. The inner border, thicker than the outer, has a shape somewhat like a fish-hook, terminating in an acute distal angle of the bone. The outer border is much shorter and has a slight convexity at the bottom of the con

cavity. The outer distal angle of the bone is broadly rounded. The second, third and fourth metacarpals have the proximal extremity broadly convex transversely and much expanded; the shaft is constricted beyond the middle into a flattened cylinder. The distal extremity is moderately expanded and squarely truncate. The third is a little shorter than the second, the fourth distinctly shorter than the third. The fourth may be recognized by the less symmetrical proximal extremity and a shallow emargination of the inner border distally. The fifth metacarpal is short and flattened. The proximal extremity is nearly transverse to the long axis, and but little convex. Its position and mode of articulation with the carpus indicate less lateral movement than exists in the other metacarpals. The distal extremity is much broader, the longer border for the articulation of the phalanx placed obliquely to the axis of the bone. The inner border is straight or gently concave; the outer border is shorter and deeply concave.

Platecarpus. The metacarpals of *Platecarpus* are less differentiated than in *Clidastes* or *Mosasaurus*. The first is somewhat flattened and is more expanded proximally than the others, its proximal articular surface being placed somewhat obliquely to the long axis of the bone. The fourth has a slight sigmoid curvature, and the fifth is shaped somewhat like the corresponding bone of *Clidastes*, with the broader extremity distal. The second, third and fourth are more expanded proximally than distally, but the discrepancy is not as great as in *Clidastes*. The proximal extremities are not as convex transversely, and all the bones are separated more widely by cartilage.

Tylosaurus. The metacarpals are more slender in *Tylosaurus* than in the other genera. The first is the broadest and stoutest, and as long as the second. It is more expanded proximally than distally, but not much. The ends are nearly transverse to the long axis, and but slightly convex. The inner border is more deeply concave than the outer. The second, third and fourth metacarpals are slender bones, scarcely distinguishable in shape from the proximal phalanges. They are only moder-

ately constricted, and the proximal extremity is but little more expanded than the distal, and both but slightly convex. The fifth is a broader and shorter bone than the others, divaricate, as in the other genera, but with the broader extremity proximally. Its proximal articular border is oblique, and the inner border is shorter and more deeply concave than the outer.

Phalanges.

Clidastes. The phalanges of *Clidastes* offer distinctive characters from those of the other genera, which will usually permit them to be referred to this genus without trouble. They are smoother and more sharply truncate at the extremities, the ends being flat or even concave. In the first finger there are four, more flattened and expanded than in the next three fingers. The first is broadly expanded proximally to correspond with the distal extremity of the metacarpal. The remaining three of the first may be distinguished from those of the next three fingers by the outer distal angle being thinned and rounded. In the fifth finger there are three; the first is flattened and much expanded proximally, but is shorter than the corresponding bone of the first finger. The second is not three times the length of its proximal extremity, and all, like those of the first finger, have a distal angle rounded. In the second, third and fourth fingers there are four or five phalanges, all of which are rather slender, markedly constricted, and with their extremities nearly symmetrical.

Platecarpus. In *Platecarpus* the phalanges resemble those of *Clidastes* more closely than those of *Tylosaurus*, and seem to be the same in number or but one or two more in the middle fingers. The bones of the first and fifth fingers are more flattened and unsymmetrical than in the other fingers, but less so than in *Clidastes*. In plate XLIV is shown a paddle of *P. ictericus* drawn by myself many years ago, as the bones lay in position.

Tylosaurus. In *Tylosaurus* the phalanges are more slender than in either of the other genera, and much more numerous. A specimen in the museum of *T. proriger*, from which the characters of the paddles have chiefly been derived, has the front

paddle almost absolutely complete and all the bones, or nearly all, in their natural relations. A photograph of the specimen is shown in plate XLVIII, and in the accompanying figure is given the outline of the bones there concealed, as determined from an excavation on the opposite side of the slab. The number of phalanges were apparently as follows: I, 6; II, 9; III, 10; IV, 11; V, 11. The distal one is preserved only in the fifth finger, and is, as is seen, very small and imperfect. I am rather inclined to the opinion that the number of phalanges is not always absolutely uniform in different individuals, though probably varying only within small limits. It will be observed that the fifth finger is longer by far than in either *Platecarpus* or *Clidastes*. It is this specimen in which the remains of the skin are preserved, described in the chapter on the restoration. Between the phalanges, even to their extremities, traces of the skin are found, from which it is evident that the membrane connecting them was very thin and pliable and extended fully to their tips. Small, scale-like scutes are found as far as the metacarpals, beyond which they are wanting everywhere.

In the plates cited above will be seen what are evidently the natural positions of the digits of the front paddles in *Platecarpus* and *Tylosaurus*. The restorations of the paddles given by Marsh are certainly unnatural and unlifelike. There is a gentle curvature of the fingers away from the radial side. While in life the fingers were probably less approximated, it is certain that the fingers were never spread, fan-like. The first finger appears to have been closely approximated to the second, and incapable of much divarication, giving support and strength to the side of the paddle. In the structure of the paddles especially, *Tylosaurus* is the most specialized of the Mosasaurs, and the least lizard-like. The paddles are the most slender, most flexible, and relatively smaller and less strong than in the other genera.

Pelvic Girdle and Extremity.

The pelvic girdle presents more characteristic generic differences than do the bones of the pectoral girdle, though in all the structure is of the same plan. The rod-like ilium ends in a

free, flattened extremity, directed obliquely upwards and forwards in life. Its union with the vertebral column is very weak, if there is any union at all. The end probably lies in relation with the first non-costiferous transverse process, though probably without any connection, inasmuch as none of these processes shows any special indication of ligamentous attachments. The pubis is flattened spatulate at the distal extremity, and, if it meets the fellow of the opposite side, the union must be slight. The ischium, on the other hand, shows a broad and somewhat flattened distal extremity of considerable thickness, especially in *Platecarpus*. Doubtless there is a true symphysis here, forming a complete pelvic girdle. The pelvis is, relatively to the pectoral girdle, the weakest in *Clidastes* and strongest in *Tylosaurus*. It is, however, absolutely the strongest and best developed in *Platecarpus* of any of the three genera.

Ilium.

Clidastes velox. The ilium in this species is a slender, somewhat flattened, rod-like bone, gently concave along the upper border, for most of its length, and correspondingly convex below. The extremity is flattened, thin, and somewhat roughened. At the acetabular end the bone is expanded into a thickened head, the anterior border curving suddenly downward, while the posterior or upper is gently convex. It has two facets of nearly equal length, the posterior one for union with the ischium, the anterior for the pubis; a third cupped surface forms part of the acetabulum. The side to which the bone belongs may be determined by the outward direction of this face. The articulations are more roughened, as they are in all the bones of the girdles and extremities, indicating a thicker covering of cartilage.

Platecarpus coryphæus. The ilium in this species is more thickened and stout than in *Clidastes*, and the facets at the proximal extremity less well marked. The upper or posterior border is gently convex, and not sinuous, the convexity greater near the acetabular end.

Tylosaurus proriger. In this species the shaft of the ilium is nearly straight throughout, there being a downward convexity toward the acetabular end. The acetabular end is relatively stout and broad, and the bone more flattened.

Pubis.

Clidastes velox. In *Clidastes* the pubis is the broadest of the pelvic bones. The acetabular end is broadly expanded, with three facets, one on either end of the border, uniting in a slight angle, for ilium and ischium, the third for the acetabulum near the middle and directed outwardly. Below the thickened end there is a moderately constricted, flattened neck, in front of the middle of which is the small pubic foramen. Below this, and directed forward, there is an obtuse, flattened process. Below this process the narrow, flattened shaft of the bone is directed downward into a flattened, somewhat spatulate blade, moderately expanded and slightly thickened at the extremity. The bone is shorter than the ilium and of about the same length as the ischium.

Platecarpus. The pubis in *Platecarpus* is intermediate in shape between that of *Clidastes* and that of *Tylosaurus.* The anterior process exists as a thicker and slightly prominent projection close to the head of the bone. The shaft is placed less obliquely to the long axis of the bone, is thicker and longer, and is considerably expanded distally. The anterior border is thinner than the posterior, nearly straight below the process. The posterior border is thick and concave, the thickened portion of the shaft lying on this side. The distal extremity is thinned on the front part, considerably thickened for the ventral symphysis on the posterior. Internally the bone is flattened longitudinally. Externally it is concave on the upper part transversely. The thickened head for articulation with the ischium is directed upward and backward, the acetabular surface back of the middle is turned outward. The pubic process anteriorly is thickened at its extremity, its oval elongate face for cartilage turned somewhat outward and connected with the cartilaginous surface of the upper part by a narrow neck.

Tylosaurus proriger. The pubis of *Tylosaurus* may be at once distinguished from the same bone in the other genera by the entire absence of the pubic process. The bone also is relatively shorter and less expanded distally. The front border has a gentle convexity from the iliac angle to beyond the middle, whence the margin is more nearly straight to the extremity. The iliac and ischiac borders occupy each about half of the upper end and meet in a slight angle. The posterior border is gently concave or nearly straight throughout nearly the whole extent.

Ischium.

Clidastes velox. The ischium of *Clidastes* has a moderately constricted neck, placed at a strong angle with the long axis of the bone; a prominent, thinned tuberosity directed directly backward, near the upper end of the bone, and separated by a shallow concavity from the acetabular surface; and a stout, thickened and expanded symphysis below. The articular surface for the pubis is nearly parallel with the long axis, and nearly at right angles with that for the ilium.

The *Platecarpus* ischium differs markedly from that of either of the other genera. The ischial tuberosity is small, the pubic face is more oblique to the long axis, and the distal extremity is greatly dilated into a long, angular projection anteriorly. The distal extremity when seen from the end presents a shallow, V-shaped figure, with the pubic border much longer and thinner, the posterior border very stout and thick. The bones evidently meet in a very firm and broad symphysis. From without the bone presents a long, obtuse ridge with the sides shallowly concave. On the inner side there is a corresponding depression.

Tylosaurus proriger. In *Tylosaurus* the bone is less stout than in *Platecarpus*, and resembles that of *Clidastes* more nearly, differing chiefly in the broader blade below, with a broader extremity and less constricted shaft above. The spinous process is more pronounced and is tipped with cartilage. A rather pronounced ridge runs from the uppermost, posterior angle downwards on the inner side, to become continuous with the inflected anterior border of the bone on the lower half. Back of

this the surface is concave above, more strongly so below. The blade of the bone below on the outer side is correspondingly convex.

Femur.

Clidastes. The femur of *Clidastes* is a relatively small, rather slender bone. The head is moderately expanded, transverse, with an oval, convex, articular surface. The trochanter, situated on the tibial side, is stout, prominent, directed nearly upward, with the large oval extremity tipped with cartilage, and narrowly separated from the articular surface of the head by a slender neck. The stout, rounded ridge of the trochanter extends below the middle of the bone. The distal extremity is more expanded than the proximal. It has a broad, thickened articular surface for the tibia, and a smaller, thinner and oblique one for the fibula. The tibial border is thickly rounded and gently concave throughout. The shorter and thinner fibular border ends in the thinner rounded lateral expansions above and below.

Platecarpus. The femur in *Platecarpus* is much like that of *Clidastes.* The trochanter is hardly as large, the extremities a little more dilated, the fibular angles a little less rounded. The distal extremity is more expanded.

Tylosaurus proriger. In *Tylosaurus* the femur is more slender than in either of the other genera, but the differences from *Platecarpus* are not great. The lower extremity is more expanded and convex, the sides more deeply concave, of nearly equal depth and length. The sides meet the lower border in an acute angle, lacking the slight convexity of *Platecarpus* and the marked convexity of *Clidastes.* The head of the trochanter stands a little lower down on the bone, and its coarse pitting for cartilage is less distinctly separated from the articular surface of the head by the smooth neck. The bone is nearly bilaterally symmetrical, except the lateral position of the trochanter. In both *Clidastes* and *Platecarpus* the bone is markedly unsymmetrical, the greater flattening and deeper concavity being on the fibular side.

Tibia.

Clidastes velox. The tibia is a moderately stout bone, articulating proximally by a thickened, oval face with the thickened articular facet of the femur. It is more flattened and expanded distally than proximally. The outer border is thick and rounded, and concave longitudinally from near the proximal angle quite to the distal articular face, which it meets in an acute angle. The outer border is thin and moderately deeply concave near the middle, the proximal end convex in outline, the distal end meeting the long convexity of the distal border in an obscure angle. The thickened face for the tarsal is on the inner third of the distal border, and is placed obliquely to the long axis. The articular surface is cupped and oval in outline.

Platecarpus. The tibia of *Platecarpus* resembles that of *Clidastes* more than that of *Tylosaurus*. It is more flattened than in *Clidastes*, less than in *Tylosaurus*. Its outer border is less deeply concave than in *Clidastes;* the articular facet for the tarsal is smaller, the inner border is longer and less deeply concave, almost wholly lacking the convex flattened expansion proximally. The curvature of the distal border does not extend as far proximally.

Tylosaurus proriger. The tibia in *Tylosaurus* is an exceedingly broad, flattened bone, the width of the distal extremity being nearly as great as the length. The outer border is gently concave throughout, while the free, inner, thin border is confined to a shallow notch on the proximal half. The outer distal angle is broadly rounded, as in *Clidastes*, the proximal less so. The proximal border is nearly straight transversely, while the distal is gently convex. There is no facet for a tarsal bone.

Fibula.

Clidastes. The fibula in *Clidastes* is characteristic. It is a small slender bone, with the distal extremity expanded fan-shape. The outer border is the thicker, concave throughout, the concavity deepest beyond the middle, the border meeting each end in nearly a rectangle. The inner side is also concave, the concavity deepest near the middle. The distal extremity is

transverse in the middle, rounded on either side. The inner part has a short, thickened facet for articulation with the large tarsal bone. The middle portion is somewhat thinner and has a facet for union with one of the smaller tarsals. The outer part of the border gives attachment to cartilage and meets the lateral border in an obtuse angle. The proximal end is oval in cross-section, the articulation placed obliquely to the long axis, with the inner angle rounded.

Platecarpus. The fibula of *Platecarpus* is not unlike the corresponding bone of *Clidastes*, but is less expanded distally and more symmetrical. The outer border is moderately and nearly evenly concave throughout. The inner border is more deeply concave, with its end slightly convex. The proximal end of the bone is about two-thirds the width of the distal and is nearly transverse. The distal end is somewhat oblique, the inner angle expanded. There is a small facet near the outer end of the border for the tarsal.

Tylosaurus proriger. The fibula in this genus is very small in proportion to the tibia, its extremities but little expanded. The lower extremity is expanded more than the upper; the sides are concave, with the greater concavity on the inner side.

Tarsus.

Clidastes. Of *Clidastes velox* there is but a single tarsal bone preserved. Of *C. westii* there are three or four. The largest is the one articulating with tibia and fibula. The broader tibial extremity has in the proximal side a large oval facet for the tibia, immediately internal to which the bone is directed proximad, with a free oval border to the distal external angle of the fibula. Nearly at right angles to this free border there is an oval articulating facet for the fibula. The outer and distal border is rounded and apparently articulates with no bones. On the inner side there are two articular facets, indistinctly separated for the smaller tarsal bones. These two bones, in *C. westii*, resemble very much the distal carpals. They are irregularly four- or five-sided, the proximal one articulating with the fibula, the outer and distal tarsals, and in part with the fifth metacarpal.

The distal one, a little smaller, articulates with the two tarsals and the metatarsal. The structure of the hind paddle in *Clidastes* is undoubtedly like that of *Mosasaurus*. See pl. XXXI, f. 8.

Platecarpus. The three tarsals preserved in *Platecarpus* show much resemblance to those of *Clidastes*. The largest is more nearly circular, with a short, deep, free notch separating the tibial and fibular faces, that of the tibia the larger and thicker. The outer border is thickened and rounded; the distal and inner side shows two or three facets for the smaller bones. These bones are proportionately smaller than in *Clidastes*. The proximal one, articulating as in *Clidastes*, is the smaller, and is broader from side to side than the length; the other is irregularly five-sided and its diameters nearly equal; its articulations are as in *Clidastes*.

Tylosaurus proriger. In *Tylosaurus* there is but a single tarsal bone, small and rounded. It probably represents the largest of the bones of *Clidastes* and *Platecarpus* and is set in cartilage opposite and between the ends of the two leg bones.

Metatarsals.

No part of the Mosasaur skeleton is known so imperfectly as the digits of the hind extremity. Of *Clidastes*, all that is known with certainty are the first and fifth metatarsals and isolated phalanges. *Platecarpus* and *Tylosaurus* are better known, still not completely.

Clidastes. The first metatarsal in *C. velox* is broadly and obliquely expanded proximally, the angles rounded. The distal extremity is much narrower and the border rectangular, with the outer angle rounded. The inner border is thicker than the outer and more deeply concave, ending more or less acutely. The fifth metatarsal in *C. westii* is a somewhat disk-shaped bone, with one side concave. The proximal and distal ends are thickened for articulation or cartilage. The proximal border is thin and semicircular. The distal border is thickened and rounded and concave. The bone evidently articulates proximally with the two smaller tarsals. Whether there is a phalanx articulating with it distally is not known, but probably not.

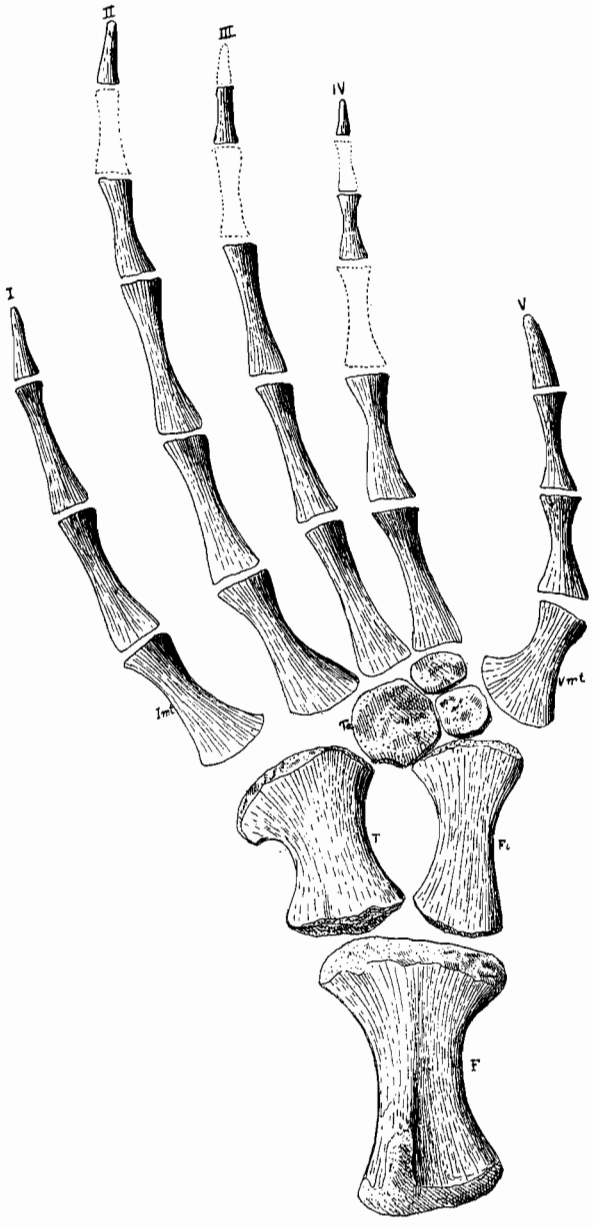


FIG. 5.

Hind paddle of *Platecarpus coryphœus*, in part after Marsh. *F*, femur; *T*, tibia; *Fi*, fibula; *Ta*, tarsals; *Imt–Vmt*, first–fifth metatarsals; *I–V*, first–fifth digits.

Platecarpus. The metatarsals of *Platecarpus* are better known than those of *Clidastes.* The first is the most expanded at the base; the second, third and fourth less so, resembling the phalanges. The fifth is most characteristic; it is thin and flattened, with the proximal extremity much expanded, gently convex and a little oblique. The distal or outer border is more thickened than the opposite, and is concave throughout. The inner or proximal border is thin and slightly concave from the prominent flattened rounded proximal angle. The distal extremity is less than half the width of the proximal, and is only moderately thickened. It is slightly oblique to the long axis of the bone.

Tylosaurus proriger. In *Tylosaurus* the first and apparently the fourth metatarsals are nearly symmetrical bones, with the base broadly expanded and convex in outline. The fifth is very much smaller—smaller relatively than in *Platecarpus,* which it resembles. It is shorter than in that genus, the extremities more oblique. The proximal articular surface is placed at an angle of about forty-five degrees with the long axis of the bone. The outer border is short and deeply concave, and thicker than the inner border. The latter is thin, short, and shallowly concave between the broadly rounded angles. The distal extremity is only a little narrower than the proximal; it is gently convex, and nearly transverse to the long axis of the bone. The bone is not twice as long as wide.

Phalanges.

Clidastes. The phalanges in this genus are of the same general character as those of the hand. Nothing is known of their number and arrangement. In all probability the digits are of a length similar to that in the hand.

Platecarpus. The number of phalanges in the first and fifth toes is probably four, and in the other toes five or six. In their general character they resemble those of the front foot.

Tylosaurus. The best information we have concerning the hind paddle of this genus is the specimen of which a photographic illustration is given (plate L). In all probability

there were about five phalanges in the first and fifth toes, and eight or nine in the others. The phalanges are more slender in this form than in the others, and somewhat less constricted. The fifth digit is evidently divaricated, and undergoing reduction, in both of which characters it differs from that of the front foot. A restoration of the paddle, as I think it should be, will be found in the restoration of *Tylosaurus*.

SYSTEMATIC DESCRIPTIONS.

For the sake of completeness and clearness I give herewith the group and generic descriptions of the known European and American Mosasaurs, rather briefly, however, save for the Kansas forms.

The determination of the species described by early authors is in large part clearly impossible in the absence of the type specimens. Species after species have been named, based largely or entirely upon mechanical distortions and mutilations. The conditions of petrifaction in the Niobrara seas were such that the bones of these animals are rarely preserved in their natural shape. Vertebræ are almost invariably flattened, and, if preserved in a vertical position, the bones are depressed; if in a horizontal position, compressed. This distortion is not readily perceived in many specimens, as cracks and breaks are usually wanting, the bones having yielded, as though of a plastic material. For this reason, very little or no dependence can be placed upon the shape of the centra. In fact, the centra in all the forms appear to have greatly resembled each other in shape during life—a rounded or slightly depressed shape in the cervical region, a more depressed or transversely oval in the dorsal, a subpentagonal or pyriform shape in the pygal, and a vertical oval in the caudal region. Just what is the norm of each genus or species it is difficult to say, and will always remain more or less of a problem. For this reason I have entirely ignored this character in the specific determinations.

In the restoration of the skull of the different genera a vast deal of study has been necessary to correct the malformations due to fossilization, the skulls fossilized in different positions

having been thoroughly studied, and all compared with the positions of the different bones in the perfectly preserved and undistorted skull of *Mosasaurus horridus* from the Fort Pierre. That all errors have been avoided in the restorations I cannot hope for; I am confident, however, that they have been reduced to a minimum. The limb bones are invariably flattened, and rarely agree exactly. If one takes into account these differences, scarcely ever will any two specimens be found alike; if one ignores them four-fifths of all the described species must be abandoned.

MOSASAURIA.

Pythonomorpha Cope, Proc. Bost. Soc. Nat. Hist., 1869, p. 253.

Large marine reptiles, varying in length between five and forty feet. Limbs wholly natatory, webbed to the extremity of the digits, and without claws, the phalanges often numerous, the arm and leg bones short and broad, and incapable of rotation upon each other, or so to a limited extent only. Pectoral girdle composed of scapula, coracoid, and (in some cases) an interclavicle, the clavicle never present. Sternum, when present, calcified. No sacrum; the anteriorly directed, rod-like ilium feebly or not at all united to the vertebral column. Pubes and ischii united in a ventral symphysis. Vertebræ procœlous, from 115 to 150 (?) in number. Cervical vertebræ seven in number, the first five or six with an articulated hypapophysis. Thoracic ribs not more than fifteen in number, single headed, attached to a stout diapophysis springing from the centrum. All the precaudal vertebræ, except the atlas, costiferous. Zygapophyses stout and strong anteriorly, becoming obsolete at the beginning of the tail, Tail elongate, as long as the precaudal series of vertebrae, more or less compressed, with elongated chevrons, save at the basal part, and with diapophyses anteriorly. Premaxillaries united with each other and with the coossified nasals. Frontal and parietal bones unpaired. A large pineal foramen present. Parietal with decurved, wing-like processes for union with petrosal and supraoccipital. Jugal arch complete. Temporal arch composed of squamosal,

prosquamosal, and post-frontal. A complete parieto-squamosal arch present. Paroccipital united with exoccipital (?). Quadrate large, free, with a large suprastapedial process, articulating proximally with prosquamosal, squamosal, and sometimes with the exoccipital (paroccipital). Transverse bone small, articulating with pterygoid and jugal only. Pterygoids elongate, approximated in front and behind, but not contiguous, united by ligament to the quadrate, and provided with numerous teeth. Palatines small, without teeth. A ball-and-socket joint between splenial and presplenial. Skull elongated and narrow.

Mosasauridæ.

Mosasauridæ Gervais, 1853.
Clidastidæ Cope, Proc. Bost. Soc. Nat. Hist., 1869.
Tylosauridæ Marsh, Amer. Journ. Sci., XII, July, 1876.
Edestosauridæ Marsh, Amer. Journ. Sci., XXI, p. 55, 1878.

TYLOSAURINÆ.

Tylosaurinæ Williston, Kans. Univ. Quart., VI, A, 180, 1897.

Hind feet functionally pentedactylate. Trunk short, the tail proportionally long, not dilated distally. Tarsus and carpus almost wholly unossified, the phalanges numerous. Vertebræ wholly without zygosphene, or, at the most, very rudimentary. Premaxillary projecting into a long rostrum in front of the teeth. Quadrate with a short suprastapedial process.

Tylosaurus.

? *Macrosaurus* Owen, Journ. Geol. Soc. Lond., 1859, 380.
? *Lesticodus* Leidy, Proc. Amer. Phil. Soc., VII, 10, 1859.
? *Nectoportheus* Cope, Proc. Amer. Phil. Soc., 1868, 181.
Rhinosaurus Marsh, Amer. Journ. Sci., III, 461, June, 1872 (preoc.)
Rhamphosaurus Cope, Proc. Acad. Nat. Sci. Phil., 1872, 141 (preoc.)
Tylosaurus Marsh, Amer. Journ. Sci., IV, 147, 1872.

Moderate to large sized species. Rostrum much produced, the nares situated far back. Facial surface of the parietal produced to the posterior part in the middle, the sides nearly parallel. Postfrontal and prefrontal meeting on the superior orbital border. Prefrontal not expanded on the facial plane

over the orbit. Quadrate with a short suprastapedial process. Humerus not broad, the proximal end angulated, the distal end without radial process. Ulna and radius slender. A single carpal or tarsal bone present, not articulating with the adjacent bones. Phalanges very numerous, the fifth finger not reduced. Hind limbs as large as the anterior. Spines of caudal vertebræ not elongated before the distal end. Thoracic vertebræ twelve to thirteen in number, the lumbo-dorsals about ten, the pygal caudals five; whole number of vertebræ not exceeding 120; no zygosphene. Coracoid not emarginate.

The rightful name of this genus cannot be determined until more is known about the forms described from incomplete material from New Jersey. It is altogether likely that *Nectoportheus* is the same, and it is possible that *Macrosaurus* and *Lesticodus* are. In this uncertainty *Tylosaurus* may be retained for the present.

Macrosaurus lævis Owen, was proposed for a genus and species represented by two dorsal vertebræ from the Green sand of New Jersey. Leidy (Cretaceous Reptilia, 75) referred other remains to the same species, but with the remark, "I cannot avoid the suspicion that both the specimens in question and those described by the high authority just mentioned [Owen] really appertain to a dorsal series of *Mosasaurus*." The vertebræ figured by Leidy seem to resemble those Kansas forms referred to *Tylosaurus*, but inasmuch as the genus is distinguished with difficulty by the vertebræ alone it would be hazardous to say with any degree of certainty that they are really the same. Cope, in 1870 (Extinct Batrachia, etc.), referred certain bones to this same species under the name *Liodon*. In the plates of the same work he figured two or three vertebræ over the name of *L. validus*, referred to *L. lævis* in the text, and to *Clidastes antivalidus* in the explanation of the plates. The different names that he used are sufficient evidence of his uncertainty.

In the Proceedings of the Boston Society of Natural History for 1869, p. 260, Cope says of *Macrosaurus:* "This genus has undoubted relationships to *Clidastes;* I have observed in a few

of its vertebræ traces of a notch, which, in the latter, separate the zygosphene from the zygapophyses. Unfortunately other portions of the genus are unknown."

Lesticodus was given by Leidy to a species (*L. impar*) represented by teeth and portions of the jaws, and was afterwards abandoned by him. Cope evidently believed that the genus was the same as *Liodon* Cope.

Nectoportheus Cope was based upon *Liodon validus* (olim *Macrosaurus*) and was characterized by him as follows (Extinct Batrachia, etc., 208): "The posterior dorsals are so much more depressed than in *Liodon lævis*, that future discovery may justify the generic separation of the genus *Nectoportheus*, which I originally applied to this animal." In his Cretaceous Vertebrata (p. 160) he says: "The typical species of this genus (*Liodon anceps* Owen) is very little known, but few remains having been obtained from the English Chalk, its locality and horizon. Numerous North American species resemble it in the forms of the crown of the teeth, and it is probable, though uncertain, that they agree in other respects also. Several names have been proposed for our species, the earliest of which is *Macrosaurus* Owen. This name applies to species with compressed dorsal vertebræ, as *L. lævis* and *L. mitchelii*, both from the New Jersey Greensand. For species with the depressed dorsal vertebræ, as *L. validus* from New Jersey, *L. perlatus* from New Jersey, and *L. proriger* from Kansas, the name *Nectoportheus* was proposed and briefly characterized."

The definition of *Tylosaurus* (*Rhinosaurus*) was explicit and exact, leaving no doubt of the genus to which it was intended to apply.

Tylosaurus proriger.

Macrosaurus proriger Cope, Proc. Acad. Nat. Sci. Phil., 1869, p. 163; Ext. Batrachia, etc., pl. XII, ff. 22–24.

Liodon proriger Cope, Ext. Batrachia, etc., 202, Cret. Vert., 161, pl. XXVII, ff. 8, 9; XXX, ff. 10–13; XXXVI, f. 2; XXXVII, f. 6.

Rhinosaurus proriger Marsh, Amer. Journ. Sci., June, 1872.

Rhamphosaurus proriger Cope, Proc. Acad. Nat. Sci. Phil., 1872, p. 41.

Tylosaurus proriger Leidy, Ext. Vert. Fauna West. Terr., 274, 344, pl. XXXV, ff. 12, 13; XXXVI, ff. 1–3. Merriam, Ueber die Pyth. der Kans.-Kreide, 14. Williston, Kans. Univ. Quart., VI, 98, pls. IX–XII; 107, pl. XIII; 177, pl. XX.

This species was the first of the Mosasaurs described from Kansas. "The original description was based upon material in the Museum of Comparative Zoology, Cambridge, Mass., brought by Prof. Louis Agassiz from the Cretaceous beds in the neighborhood of Monument, Kan., and near the line of the Kansas Pacific road." The locality thus given by Cope is not exact. The specimen was undoubtedly found in the vicinity of Monument Rocks, the old overland stage station, which is not near the railroad, while the station, Monument, is not near any Cretaceous outcrops. The species is the most common of this genus, and has been found at nearly all horizons in the Niobrara beds. The characters of the species have been fully given in the preceding descriptions, and need not be repeated here.

Tylosaurus dyspelor.

Liodon dyspelor Cope, Proc. Amer. Phil. Soc., 1870, p. 574; 1871; Cret. Vert., 167, pls. xxviii, ff. 1–7; xxix, xxxiii.

Rhinosaurus dyspelor Marsh, Amer. Journ. Sci., June, 1872.

Tylosaurus dyspelor Leidy, Ext. Vert. Fauna West. Terr., 271, pl. xxxv, ff. 1–11; Merriam, Ueber die Pyth. der Kans.-Kreide, 14.

This species, the largest of the Kansas Mosasaurs, was originally described from a specimen obtained from the Niobrara chalk near Fort McRae, N. M. It is the only species of the group found in Kansas that is known to occur elsewhere.

The differences that Cope gives for the species are as follows: "The palatine bones are more slender anteriorly, and the outer edge descends lowest in a ridge; in *L. proriger*, the inner is produced downward as a longitudinal rib. In this species there are eleven teeth; in that one, nine. The quadrate bone of *L. proriger* presents a longer internal angle, and more prominent internal ridge, with smaller space inclosed by the basis of the great ala." These characters are not correct. The "palatines," *i. e.*, the pterygoids, are quite alike anteriorly. In a specimen of *T. dyspelor* I count eleven teeth, as stated by Cope; in two specimens of *T. proriger* I find ten teeth, and I do not doubt but that in others there may be eleven, or that in specimens of *T. dyspelor* there may not be more than ten. This variation is also affirmed

by Merriam. The following specific differences are given by Merriam:

(1) The mandible, which is not truncated at the tip, but rounded and narrow. (2) The basioccipital, whose hypapophyses are not so strongly compressed, and, parallel to the longitudinal axis of the head, are scarcely half as broad as in *T. proriger* and *T. micromus*. (3) The pterygoids send out the transverse process in the vicinity of the sixth tooth. (4) The maxillary teeth, which are rounder, with almost no facets on the outer side or striations, while the inner side shows a strong striation.

(1) In two pairs of mandibles of each species I can distinguish no differences in the front end. (2) I can distinguish no differences in the shape of the hypapophyses that are not due to post-mortem origin. (3) In the pterygoids of *T. dyspelor* the two bones of one skull send off the transverse process opposite the seventh and eighth teeth, precisely where they are in *T. proriger*. (4) The teeth of *T. dyspelor* seem stouter, and possibly the characters given may be correct, but I am in doubt. I cannot find characters about which I feel assured. Nevertheless, there can be no doubt but what the two species are distinct. At present, however, this distinction must rest chiefly upon the very much greater size of *T. dyspelor*, rather than upon structural characters. Here, as so commonly elsewhere, the specific characters have been generally obliterated by the compression and distortion of the bones. The skull of *T. dyspelor* measures forty inches in length from the tip of the rostrum to the condyle, and the mandible is forty-eight inches long. The quadrate has a length of seven inches.

Tylosaurus micromus.

Rhinosaurus micromus Marsh, Amer. Journ. Sci., June, 1872, pl. XIII, ff. 1, 2.
Liodon micromus Cope, Cret. Vert., 271.
Tylosaurus micromus Merriam, Ueber die Pyth., etc., 24, pl. I, f. 3.

Scarcely any of the original characters given by the author of this species are valid. In *T. proriger*, "which is three or four times larger than the present species, the cervical vertebræ have vertically ovate articular faces," while in *T. micromus* "the cervical vertebræ have the articular faces but slightly

transverse." As the cervical vertebræ of all the species have the faces "slightly transverse," this character is not good for much. Merriam, l. c., who believed that he had identified this species, says that it is distinguished from *T. dyspelor* and *T. proriger* "by its smaller size, by the more lightly formed bones of the skeleton, and by the shape of the quadrate, which has a somewhat longer suprastapedial process, and a larger stapedial groove, and on the upper, inner angle is not so acute."

Tylosaurus nepæolicus.

Liodon nepæolicus Cope, Hayden's Bull. U. S. Geol. Surv. of the Terr., 1874, p. 37; Cret. Vert., 177, 271, pl. xxxv, ff. 11-13.

This was based upon the mandible and parts of the maxilla and premaxilla, the quadrate, a dorsal vertebra, etc. "It is about the same size as *T. micromus* Marsh, but is much more like the *T. proriger* in character. As compared with *T. micromus*, this species differs in the much less attenuated premaxillary and maxillary bones, the anterior nostril, and absence of facets on the crowns of the teeth; from *T. proriger*, in the absence of narrow concave facets on the anterior teeth, and anterior position of the nostril; from *T. dyspelor*, in the less compressed or less knife-shaped dental crowns, and totally different form of the condyle of the quadrate. The total length of the jaw was twenty-six inches—the length of the quadrate about three inches and a half."

The characters given—such as may be valid—are altogether too slight to distinguish the species, and I do not believe that *T. nepæolicus* is entitled to recognition.

There is a very small specimen of a *Tylosaurus* in the museum collection, which may possibly belong to either this or the preceding species, but I believe that it is only the young of *T. proriger*. The humerus measures but three inches in length, the pubis five. The shape of various bones, especially the pelvic ones, is different from those of the other specimens, and, were one to depend upon such characters, it would be easy to construct a species. The bones show much compression; they were evidently more largely composed of organic matter than are the bones usually—a condition expected of young animals.

Hainosaurus.

Hainosaurus Dollo, Premiere Note sur le Hainosaure, mosasaurien nouveau de la craie brune phosphatee de Mesvin-Cipley, Bull. Mus. Roy. Hist. Nat. Belg., 1885, II, p. 297.

Rostrum much prolonged in front of the teeth. Suprastapedial process of quadrate short. Frontal broad, the prefrontal and postfrontal touching each other. Carpals reduced in number. Typical species, *Hainosaurus bernardi* Dollo, *loc. cit.*

This genus is very closely allied to *Tylosaurus*. The phalanges of the front feet are not as numerous, and the paddle is relatively larger. There are, apparently, more numerous dorsolumbar vertebræ. Like *Tylosaurus*, it includes some of the largest species of the Mosasaurs.

PLATECARPINÆ.

Platecarpinæ Williston, Kans. Univ. Quart., VII, A, 181, 1897.

Hind limbs functionally pentedactylate. Trunk short; the tail proportionally long, not dilated distally. Carpus and tarsus imperfectly ossified. Vertebræ with rudimentary or functional (?) zygosphene. Premaxillary not projecting beyond the teeth, very obtuse. Quadrate large, with a long suprastapedial process, not united to infrastapedial process.

Platecarpus.

Holcodus Gibbes, Smiths. Contr., II, p. 9, 1850.
Platecarpus Cope, Proc. Bost. Soc. Nat. Hist., XII, 1869, p. 264.
Lestosaurus Marsh, Amer. Journ. Sci., June, 1872.

Medium-sized Mosasaurs. Premaxillary short and obtuse, projecting very slightly beyond the teeth. Teeth slender, and recurved, faceted upon the outer side and striate on the inner. Nares much dilated anteriorly, situated forward. Frontal emarginated in the middle behind; pineal foramen large, situated near the frontal suture. Facial surface of parietal small, triangular in shape, the apex not extending beyond the middle of the bone. Prosquamosal with a dilated wing-like process above. Quadrate large, with a large suprastapedial process, reaching below the middle of the bone. Expanded portion of palatine short. Coronoid short and not prominent. Zygo-

sphenes of vertebræ rudimentary. Cervical vertebræ seven in number. Thoracic vertebræ not more than fifteen in number, lumbo-dorsals nine or ten; pygial caudals five or six; chevrons large, articulated; spines of caudals regular in length. Limbs relatively large; arm and leg bones short and expanded; three or four carpal or tarsal bones present, closely articulating; pollex and hallux shorter than the fourth digit, divaricated. Coracoid with a deep emargination. Pelvic bones large; ischium much expanded distally; pubis without antero-proximal process.

The genus *Holcodus* Gibbes was proposed for the reception of a species supposed by him to be represented by three teeth from Alabama, South Carolina, and New Jersey. Two of these were figured in his work (pl. III, ff. 6–9), with the following description: "They are solid, and resemble in their pyramidal form those of *Mosasaurus hoffmani* antero-posteriorly, the dividing ridges making the anterior and posterior surfaces equal, and they are both convex. They are also acutely pointed. In *Mosasaurus* the outer surface is plane or nearly so, and both have longitudinal narrow planes near the base. . . . In the teeth under notice, on the outer half are many planes, almost grooves, and also on the inner face, which is peculiarly striated toward the base. As the striated character is a structural distinction, the name *Holcodus* is given to the genus, and that of *acutidens* to the species." Professor Leidy afterward[56] showed that only the tooth from Alabama belonged to a Mosasauroid, the one from New Jersey being that of a crocodile (*Hyposaurus*). He describes Gibbes's type as follows (*op. cit.*): "The specimen has the enameled crown three-fourths of an inch in length. The base is elliptical in transverse section, and measures five lines antero-posteriorly, and four lines transversely. The crown is nearly equally divided by acute ridges, which are imperfect in the specimen, but appear not to have been denticulated. The surfaces are subdivided into narrow, slightly depressed planes, and the inner one is strongly striate

56. Cretaceous Reptiles of the United States, p. 32, foot-note.

at the base." He is inclined to refer the tooth to *Mosasaurus*, a view in which Marsh coincides after examination of the type.[57]

I cannot agree with these authors. Whatever the tooth may be, it is not that of a *Mosasaurus*. Professor Cope erected the genus *Platecarpus* for a species which Leidy had previously referred to *Holcodus*, under the name *tympaniticus*. The specimen which he described was from Mississippi. Later Cope applied the name *Holcodus* to two species from Kansas (*H. coryphæus and H. ictericus*), but which he later placed in *Platecarpus*, after the name *Lestosaurus* had been given to the genus represented by them. In his Cretaceous Vertebrata (p. 141) he says: "The teeth of the Kansas species referred to it are somewhat similar in character to those described by Gibbes; but it is evident that the latter belonged to a different animal more nearly allied to the true *Mosasaurus*." Of *Platecarpus tympaniticus* very little of the skeleton has been described, and the tail is not yet known. At one time (Ext. Batr., etc.) Cope stated that the tail vertebræ of *Platecarpus* had coossified chevrons, upon what authority I cannot learn. Marsh based the distinction of *Lestosaurus* largely upon that character, apparently following Cope. The quadrate of *P. tympaniticus*, as figured by Cope, certainly looks very much like that bone of the Kansas species, and the quadrate in this genus is a very characteristic bone. These questions then, are to be settled before the name *Platecarpus* can be finally accepted for the Kansas forms: First, is the typical *Platecarpus* identical with the *Holcodus?* I believe that it is. The teeth of the Kansas forms agree perfectly with Leidy's description and figure of the type specimen of *Holcodus*. Second, is *P. tympaniticus* congeneric with the Kansas species placed in this genus? This also appears to be true, but it is by no means yet proven. If both propositions are true, our species must be known as *Holcodus*. If the latter only is true, *Platecarpus* will be retained; while if the former is alone true, the name *Lestosaurus* will take precedence. It is a pity that little or nothing has been added to our knowledge of the southern and eastern species of this

57. American Jour. Sci., June, 1872.

group within the last twenty years. Perhaps we may expect more definite knowledge concerning them in the immediate future. There is no inherent improbability that the Alabama or Mississippi species are not congeneric with the western ones, inasmuch as we know positively that one genus at least, *Clidastes*, does occur in all these regions, and it does not seem at all unlikely that all of them are common to the different horizons.

? Platecarpus crassartus.

Liodon crassartus Cope, Proc. Amer. Phil. Soc., 1871, 168.
Platecarpus crassartus Cope, Cret. Vert., 153, 268, pl. xxvi, ff. 4, 12.

This species is known only from Cope's description. Its locality is given from Eagle Tail, in Colorado. The fact is, however, that the locality whence it was discovered is within the borders of Kansas. I visited the precise place of its discovery in company with Professor Mudge, who discovered it many years ago. The horizon is not Niobrara, but clearly Fort Pierre. The species does not belong in the genus *Platecarpus;* of that I feel confident. It evidently has strong relationships with *Brachysaurus*, and I would have referred it to that genus save for the free chevrons. As it is, I am not sure but that it may belong there, or perhaps better in *Prognathosaurus* Dollo.

The peculiar robust condition of the bones is not, however, the most characteristic peculiarity of the species. Bones wherever found in the Fort Pierre invariably have a solidity and thickness never seen in the specimens from the Niobrara. I am confident that the limb bones of the various forms known from the Niobrara had the general robustness seen in this, but have always been flattened and compressed in fossilization. Better characters are found in their shape. Especially is the relative size of the limb bones and vertebræ different from that in *Platecarpus*, the limbs being evidently much smaller. Copies of the principal figures given by Cope are reproduced in plate xlv, which will enable the species to be again recognized. I have no doubt but that future discovery will bring to light much better specimens of this species from the Fort Pierre out-

crops in Colorado. The measurements given by Cope are as follows:

"Length of humerus	100 mm.
Proximal diameter of same	95
Distal diameter of same	102
Length of femur	80
Proximal diameter of same	65
Length of a centrum of a dorsal vertebræ without ball	61
Transverse diameter of cup	60
Vertical diameter of cup	53
Length of a pygal vertebra	55
Transverse diameter of ball of same	60
Length of caudal	41
Depth of ball	52
Width of ball	52

"The vertebræ are as much distinguished for their shortness as those of *P. latispinis* are for their elongation. The articular faces are but little broader than deep, and their planes are slightly oblique. The inferior face is somewhat concave in the longitudinal direction. The zygapophyses are stout, and there are no distinct rudiments of zygosphene. The pygals and anterior caudals have round articular surfaces. One of the latter with strong diapophyses, but posterior, is subpentagonal in outline of cup."

? Platecarpus latispinis.

Liodon latispinis Cope, Proc. Amer. Phil. Soc., Dec. 1871.
Platecarpus latispinis Cope, Cret. Vert., 156, pl. xxviii, ff. 1–4.
? Platecarpus latispinis Cope, *op. cit.* 368.

This species is also from the Fort Pierre, and very doubtfully belongs in this genus. There is not enough of the type specimen preserved and described by Cope to locate it definitely. It will, however, some time be recognized, I am confident, and for that reason I give Cope's description fully.

"The remains representing this species consist of seven cervical and dorsal vertebræ; five of them being continuous and inclosed in a clay concretion. The type specimens were found by Prof. B. F. Mudge, one mile southwest of Sheridan, near the 'Gypsum Buttes.' These display the elongate character seen in *Liodon lævis*, etc., but the transverse surfaces are transversely

oval, thus resembling the *P. ictericus*. The cup and ball of the penultimate cervical are a little more transverse than those of the fourth dorsal, and none of them are excavated above for the neural canal. The last cervical is strongly keeled on the middle line below, and with a short, obtuse hypapophysis marking the beginning of the posterior third of the length; the median line of the first dorsal has an obtuse ridge. There is no keel on the fourth dorsal, but the lower surface is concave on the antero-posterior direction. The diapophysis on the last two cervical and first three dorsal vertebræ have great vertical extent; the articular surface for the rib is not bent at right angles on the first dorsal. Neural arches and spines are well preserved in most of the specimens. There is no trace of a zygantrum. The neural spines are flat, and have considerable antero-posterior extent on cervical as well as dorsal vertebræ, and are truncate above. First dorsal bears a long, strong rib."

"Transverse diameter of cup of penultimate cervical vertebra.....	51 mm.
Length of centrum of fourth dorsal, without ball.....	72
Vertical diameter of the ball.....	45
Transverse diameter of same.....	65

Platecarpus glandiferus.

Liodon glandiferus Cope, Proc. Amer. Phil. Soc., Dec. 1871.
Platecarpus glandiferus Cope, Cret. Vert., 156, 168, pl. xxvi, ff. 13, 14.

This species was based upon very slight material. Nevertheless it is possible that it may again be recognized. The two cervical vertebræ upon which it is based were collected from "lower Butte creek" and "one mile southeast of Sheridan." If the locality is accurately given, the second specimen was assuredly from the Fort Pierre. The other specimen must have been in the Niobrara. Unfortunately it is not stated which of the vertebræ was from the North Fork and which from Butte creek. I doubt that the vertebræ are sufficiently characteristic to positively determine the species, but they may be. I give Cope's description and a reproduction of his figures:

"One is an anterior, the other a posterior cervical vertebra. The articular sufaces are transversely elliptic, and completely rounded above; that is, neither truncated nor excavated for the

neural canal. This shorter axes are oblique, *i. e.*, make less than a right angle with the long axis of the centrum; and the articular surface of the ball is thus carried forward on the upper face to much nearer the base of the neurapophysis than usual, in the anterior vertebra nearly touching them. The ball is, likewise, more convex than in any other species, having a slight central prominence in the posterior vertebra. There is no annular groove around the ball. In both, the articular surface of the hypapophysis is truncate and bounded by an elevation in front, a peculiarity not observed in any of the species above described. There is no trace of a zygosphene in either. In the anterior vertebra the diapophyses are nearly horizontal; the posterior portion slightly thickened and oblique. The anterior portion is thinned out, and very rugose above and below, and does not continue its margin into the rim of the cup. In the second vertebra the diapophyses are very large, vertical, and with a horizontal portion rising in a curve to join the middle of the lateral margin of the cup. Neural spine narrowed above and keeled behind.

"Length of centrum of anterior vertebra	64 mm.
Vertical diameter of ball	30
Transverse diameter of same	39
Length of posterior vertebra	64
Vertical diameter of ball	30
Transverse diameter of same	43
Expanse of the anterior zygapophyses	55

Platecarpus tectulus.

Holcodus tectulus Cope, Proc. Amer. Phil. Soc., Dec. 1871.
Platecarpus tectulus Cope, Cret. Vert., 159, 269, pl. xxi, ff. 3–6; xxvii, ff. 5–10.

"Established on a number of cervical and dorsal vertebræ of smaller size than those characteristic of the other species of the genus. The centra have not suffered from distortion under pressure. The articular surfaces are depressed transverse-elliptic in outline with a slight superior excavation for the neural canal. A well-marked constriction surrounds the ball.

"There is a rudimental zygosphene, in the form of an acute ridge rising from the inner base of the zygapophysis, and unit-

ing with its fellow of the other side, forming a production of the roof of the neural canal. The combined keels become continuous with the anterior acute edge of the neural spine. Thus the form is quite different from that seen in *P. mudgei*, and constitutes a lower grade of rudiment. The fact that this zygosphenal roof is separated on each side from the zygapophyses by an acute groove gives the former a distinctness more apparent than real:

"Length of median cervical	43mm.
Diameter of the ball of a median cervical, vertical	20
Diameter of the ball of a median cervical, transverse	33
Length of the anterior dorsal	42
Width of the cup	32

This species was from Butte Creek, "fourteen miles south of Fort Wallace." If this locality is correctly given it may be that the horizon is Fort Pierre. The author speaks of the species as the "smallest known *Platecarpus*." A second specimen, discovered by Mudge from the vicinity of Sheridan, must necessarily be of the Fort Pierre. The material is so very fragmentary from both of these localities that I cannot venture an opinion as to the exact affinities of the species. If a *Platecarpus*, it is probably distinct from any others.

Platecarpus ictericus.

Holcodus ictericus Cope, Proc. Amer. Phil. Soc., 1870, 577; ibid., Dec. 1871.
Lestosauras ictericus Marsh, Amer. Journ. Sci., June, 1872.
Platecarpus ictericus Cope, Cret. Vert., 149, 267, pl. XIV, f. 4; XV, f. 2; XVII, ff. 3, 4; XVIII, f. 6; XIX, f. 9; XX, f. 1; XXV; XXXVI, f. 7; XXXVII, f. 6.

This species was the first of the genus described from Kansas. Several specimens in our collection may be referred to it with tolerable certainty. Just what the essential specific characters are I am not prepared to state. The size, however, which is materially greater than any other, is apparently constant.

In pl. XLIV is given a figure of the front paddle, reproduced from a drawing made in the field by myself in 1875. I cannot say at this time that the drawing is accurate in all details, but from the care taken in its production I believe that it is. It was made natural size, and bears the following in my own writing: "Found by Prof. B. F. Mudge, South Fork Solomon

river, Graham county, Kansas, May 27, 1875. Under surface of right fore paddle, sketched in original position, natural size. Size of head, twenty-three inches from tip of snout to occipital condyle. Scapula opposite sixth cervical vertebra (measurements accurate). No. 68." The specimen is at present preserved in Yale museum under the above number, and the accuracy of the drawing may be determined whenever the material in that collection is studied. Measurements of every bone, and the distances between the adjacent ones were given in the drawing.

The drawing is especially valuable as showing the natural position of the digits and their relations to each other. The carpal bones have been partially dislodged, and the four inner metacarpals somewhat disturbed. At the tip of the third finger there was a small oval ossicle, and at the end of the radius a small nodule which was marked "sesamoid?". It was evidently cartilaginous.

By comparison with Marsh's figure of his *Platecarpus simus*, distinct differences will be seen in the shape of metacarpals. These shapes are observed in the material in our collection referred to *P. coryphæus*. It seems evident from the drawing that there were at least four phalanges in the first finger, six in the second and third, five in the fourth, and four in the fifth.

The size of the head, as compared with the paddle, it is seen is very small. The length of the paddle as drawn was twenty-nine inches, and it was at least two inches longer; that is, the proportion was as twenty-three to thirty. In *Platecarpus coryphæus* it was as twenty-one to about twenty-three; in *Clidastes velox*, as fifteen to about ten; in *Tylosaurus proriger*, as thirty-six to twenty-four.

The following measurements of the types by Cope agree with the specimens in our collection:

"Quadrate greatest length	99 mm.
Anterior dorsal, length of centrum	59
Posterior dorsal, length of centrum	55
Scapula, length	145
Humerus, length	154
Radius, length	115

Characteristic differences, other than those of size, absolutely and relatively, are hard to find. Nevertheless I believe that the species will be recognized.

Platecarpus coryphæus.

? *Liodon mudgei* Cope, Proc. Amer. Phil. Soc., 1870, p. 581.
Holcodus coryphæus Cope, Proc. Amer. Phil. Soc., Dec. 1871.
? *Lestosaurus gracilis* Marsh, Amer. Journ. Sci., June, 1872.
? *Lestosaurus simus* Marsh, Amer. Journ. Sci., June, 1872.
Platecarpus coryphæus Cope, Cret. Vert., 142, 267, pl. XIV, f. 3; XV, f. 1; XVI, f. 1; XVII, f. 6; XX, f. 4; XXI, ff. 1, 2; XXXVI, f. 6; XXXVII, f. 9; Baur, Journ. Morph., VII, 1; Merriam, Ueber die Pyth. der Kans.-Kreide, 30; Williston, Kans. Univ. Quart., VI, pl. X.

This species is the best known of the Kansas Mosasaurs, and the most common. Possibly this is due to the fact that it was the best described. "The specimens upon which this species rests were discovered by Prof. B. F. Mudge, formerly State Geologist of Kansas, now professor of geology in the State Agricultural College of Kansas, on the north bank of the Smoky Hill river, thirty miles east of Fort Wallace, Kan."

The description of the species will be found in detail in the comparative anatomical description, and numerous figures and the restoration will be found in the plates.

I believe that I recognize at least three synonyms, *P. mudgei* Cope, *P. gracilis* and *P. simus* Marsh. From the inadequacy of the descriptions of these species I may be in error. Nothing but an examination of the type specimens will determine the matter. Should *P. mudgei* be found identical, the name must supersede *coryphæus*.

I give, however, the descriptions of all three of these species quoted from their authors.

Platecarpus mudgei.

Liodon mudgei Cope, Proc. Amer. Phil. Soc., 1870, 581.
Holcodus mudgei Cope, l. c., 1871, December.
Rhinosaurus mudgei Marsh, Amer. Journ. Sci., June, 1872.
Platecarpus mudgei Cope, Cret. Vert., 157, 268, pl. XVI, f. 3; XVII, f. 5; XXVI, f. 3; XXXVII, f. 7.

"The characters distinguishing this saurian are the following: Vertebræ without rudimental zygosphene; quadrate bones

with plane surfaces from the proximal articular surface and the external obtuse-angled ridge to the meatal pit; the latter, therefore, not sunk in a depression, as in the other species.

"The determination of this species rests on a series of specimens from the yellow chalk at a point six miles south of Sheridan, Kan. They consist of three vertebræ and fragments of atlas, with numerous portions of cranium and proximal extremity of scapula."

The determination of this species may be doubtful, but, as only one species in the genus from Kansas antedates it, *P. ictericus*, the name, fortunately, must be eventually acknowledged as of a valid species, should it not be identical with *H. ictericus*. I suspect that the species is identical with *P. coryphæus*.

Platecarpus gracilis.

Lestosaurus gracilis Marsh, Amer. Journ. Sci., June, 1872.

"A marked feature in this skull of this species is the superior surface of the parietals, which is small and subtriangular in outline, with the sides incurved. The internal angle of the proximal end of the quadrate is much less than a right angle, although the great ala is nearly in the same plane as the outer margin of the hook. This leaves a deep, broad notch between the alar process and the internal angle. There is a deep groove below the meatal pit. The articular ends of the cervical and dorsal vertebræ are transversal oval, with a distinct excavation on the superior margin. Rudimentary zygosphene present. Smoky Hill river.

"Length of parietal on median line	46 mm.
Width in front	80
Length of quadrate	76
Length of centrum of axis	53

Not a single character is given in the above description to distinguish the species, except possibly the smaller size. It may be referred to *P. coryphæus* with safety. The position of the trochanter of the femur was doubtless due to post-mortem distortion.

Platecarpus simus.

Lestosaurus simus Marsh, Amer. Journ. Sci., June, 1872.

"There are eleven teeth in the maxilla, and thirteen in the mandible. The teeth have their external faces faceted, and marked with irregular striæ, and the inner side strongly striate. The quadrate is large, with a stout elongated hook. The internal angle is nearly a right angle. The distal articular face is prominently convex, with its anterior margin but slightly inflected. There is a large tubercle on the inner margin of the hook opposite the meatal pit, but no articular button. The cervical and dorsal vertebræ have transverse, broadly oval articular faces, slightly emarginated above for the neural canal.

"Length of alveolar portion of dentary	275 mm.
Length of quadrate	93
Length of axis with odontoid	98
Length of centrum of first dorsal vertebra	58
Length of humerus	141
Length of radius	99
Length of ulna	104
Length of ilium	153
Length of ischium	138
Length of pubis	175
Length of femur	116
Length of tibia	56

"This species may be distinguished from *Liodon curtirostris* Cope, perhaps its nearest known ally, but a smaller species, by the number of teeth in the maxillary, which are eleven instead of ten, by the more anterior nareal expanse, and by the supra-occipital keel, which is inclined obliquely forward. The two latter characters separate it also from *Holcodus coryphæus* Cope, from which it likewise differs in its large quadrate. Smoky Hill river." All utterly worthless characters.

Platecarpus planifrons.

Clidastes planifrons Cope, Hayden's Bull. U. S. Geol. Surv., No. 2, p. 31, 31, 1874; Cret. Vert., 135, 265, pls. xxii, xxiii, ff. 1–13; xxxv, f. 16.

? *Sironectes anguliferus* Cope, Bull. U. S. Geol. Surv., No. 2, p. 34; Cret. Vert., 139, 267, pls. xxxiii, ff. 16–18; xxxiv, 1–15, 1875.

The material upon which this species was based is "a large part of the cranium, including the quadrate bone, cervical and

dorsal vertebræ and fragments of other elements, all belonging to one individual." Notwithstanding the apparently functional zygosphene, the species evidently belongs in *Platecarpus*, and doubtless would have been located there or in *Sironectes* had the caudal vertebræ been preserved in the type specimen. This is apparent from the parietal bone, which, though incomplete, was evidently of the peculiar *Platecarpus* type; from the shape of the frontal, prefrontal, coronoid and vertebral bones. The vertebræ differ in no important respect from those of *Sironectes anguliferus*, apparently, and the presence of the zygosphenes makes it evident that the species are very closely allied if not identical.

Platecarpus felix.

Lestosaurus felix Marsh, Amer. Journ. Sci., June, 1872.

The larger part of the description of this species is drawn from illusory characters—characters due to the amount of pressure and distortion the specimen has received. In no species of the order does the supraoccipital keel, for instance, incline obliquely backward, to project beyond the basioccipital condyle.

"There are eleven teeth on the maxillary, and twelve in the mandible. The great ala of the quadrate is nearly in the same plane as the external margin of the hook, and hence the inner angle is much greater than a right angle. There is a broad, shallow depression on the front face of the ala near the middle, and below this a deep pit on the inner face above the internal angle at the distal end.

"Width of maxillary at anterior nareal expanse	33 mm.
Width of frontal at posterior margin	115
Length of quadrate	81
Length of axis without odontoid process	48
Length of anterior dorsal vertebra	60

Platecarpus latifrons.

Lestosaurus latifrons Marsh, Amer. Journ. Sci., June, 1872.

"The frontals in this species are broad, especially anterior to the orbits, where there is a lateral expansion. Eleven maxillar, twelve mandibular and ten pterygoid teeth. The quadrate has an elongate depression on the back of the ala near the middle,

and a deep semicircular excavation under the hook and behind the meatus. The cervical vertebræ are small, their articular ends elliptical, with no superior emargination. Rudimentary zygosphene present. Distinguished from *L. curtirostris* and *H. coryphæus* Cope by the number of teeth in the jaws, or palatines. Smoky Hill river.

"Width of frontals between posterior angles	115 mm.
Width in front of orbits	85
Length of quadrates	77
Length of axis with odontoid process	68

Platecarpus clidastoides.

Platecarpus clidastoides Merriam, Ueber die Pyth. der Kans.-Kreide. 30.

"This species is based upon a parietal, the entire occiput, the quadrato jugal [prosquamosal], the atlas, some dorsal and three caudal vertebræ. It is characterized by the peculiar parietal, that shows anteriorly a low, three-cornered field, in whose middle is the comparatively small, round pineal foramen, which is situated remote from the coronal suture. The parietal is vertically flattened at its posterior end, and shows much resemblance to that of *Clidastes*. The entire appearance of this bone is different throughout from that of other species of *Platecarpus*. That the species belongs to this genus is shown by the perforate basioccipital, and the *Platecarpus*-like lateral piece of the atlas. The vertebræ are so much crushed and weathered that they can be distinguished neither as belonging to *Clidastes* nor *Platecarpus*." Translation from Merriam, l. c. The specimen was collected by Sternberg on the Smoky Hill river, though whether from the Niobrara or Pierre is not certain.

Platecarpus oxyrhinus.

Platecarpus oxyrhinus Merriam, Ueber die Pyth. der Kans.-Kreide, 30.

"This species is based upon two maxillæ, a premaxilla, fragments of a dental, transverse, femur, and ulna. The character by which it is strongly distinguished from all other species, is the elongation of the rostrum, as in *Clidastes*, only the elongation is not as great." Translation from Merriam, l. c. The locality and the collector are the same as of the preceding species.

Plioplatecarpus.

Plioplatecarpus Dollo, Note sur l'osteologie de Mosasauridæ, Bull. Mus. Roy. Hist. Nat. Belg., I, 1882, p. 62.

Oterognathus Dollo, Premier Note sur les Mosasauriens de Mesvin, Bull. Soc. Belg. Geol. Pal. Hydr., III, 1889, 286.

Premaxillary obtuse, not projecting beyond the teeth. Teeth long and slender, faceted and striated. Suprastapedial process of quadrate long; ear cavity large. Mandible slender, the coronoid rudimentary. Chevrons free, not large. Coracoid emarginate. An interclavicle present. Humerus stout. Zygosphenes rudimentary. Type species, *P. marshii* Dollo, l. c. Maestrichtian.

This genus was originally made the type of a new family, based upon the supposed union of vertebræ to form a sacrum. This was afterwards found to be an error by the author and the family withdrawn. The genus certainly belongs in the vicinity of *Platecarpus*, though abundantly distinct, especially in the peculiar shape of the limb bones, as figured, in the mandible, etc.

Prognathosaurus.

Prognathosaurus Dollo, Premiere Note sur le Mosasauriens de Mesvin, Mem. Soc. Belg. Geol., III, 293, 1889.

Premaxillary short, not projecting beyond the teeth. Frontal large and triangular. Prefrontal and postfrontal touching each other. Sclerotic ring conical. Pterygoid with very large teeth. Quadrate with the suprastapedial process strong, coossified with the infrastapedial process below, inclosing an oval auditory meatus. Mandible strong, more or less campylorhynchous,[58] with a large coronoid process. Parietal foramen of moderate size. Hypapophyses of cervical vertebræ free. No zygosphene; chevrons articulated. Coracoid without emargination. Typical species, *P. solvayi* Dollo, l. c. Brown Phosphatic Chalk of Cipley, Upper Senonian.

58. That is, curved, with its upper border concave.

Brachysaurus.

Brachysaurus Williston, Kans. Univ. Quart., VI, 1897.

Premaxillary probably obtuse. Frontal large and broad. Suprastapedial process of quadrate united with infrastapedial process. No median basioccipital canal. No zygosphene ; chevrons coossified.

This genus is yet in large part unknown. As will be seen, there are many striking points of resemblance to *Prognathosaurus*, and I am inclined to suspect that the two genera may yet be found to be identical. The chief distinction, and which, if true, will certainly distinguish the genera, is the union of the chevrons. In *Prognathosaurus* they are free, while in *Brachysaurus* they are coossified, or at least some of them are. The entire chevrons are not preserved in any specimen, but the broken ends indicate clearly that the union was not by articulation. Dollo states, on page 298 of the work cited, that the chevrons are coossified in *Prognathosaurus*, but on the following page that they are free. In a later publication, however, he says that they are free, as determined from additional specimens. If the bone I identify as a part of the pterygoid is really that, the teeth are very large, thus agreeing with the most striking character of the genus *Prognathosaurus*. The species has been described in the foregoing papers, and will be found figured in plates XXX and LXII. Typical species, *B. overtonii* Williston, Kans. Univ. Quart., III, 169, 1895. Geological horizon, Fort Pierre Cretaceous of South Dakota.

Holosaurus.

Holosaurus Marsh, Amer. Journ. Sci., Jan. 1880.

Nothing further is known of this genus than the original description by Professor Marsh. Whether it is a good genus or not cannot be stated with any degree of certainty. The only essential character given by the author to separate it from *Platecarpus* is the non-emargination of the coracoid. As this same character is disregarded in *Clidastes*, it would hardly seem to be of value in this, if there are no other characters.

I give the original description, as follows:

Holosaurus abruptus Marsh, l. c. "The type specimen on which the present genus is based is one of the most complete skeletons of the Mosasauroid reptiles yet discovered. This genus is most nearly related to *Lestosaurus* [*Platecarpus*], and agrees with it in the form and general characters of the skull. It may be readily distinguished by the coracoid, which is entirely without emarginations, as well as by other points of difference. From *Tylosaurus* it is separated widely by the premaxillaries, mandibles, and the palatines.

"The present species was one of the shortest in proportion to the bulk hitherto described, the skull and tail being both abruptly terminated. The entire length was about twenty feet. There are ninety-eight vertebræ preserved between the skull and a point in the tail where the caudals have a diameter of one inch. Many of these vertebræ are in position. The caudals preserved all have articulated chevrons.

"Some of the dimensions of the present specimen are as follows:

"Length of entire lower jaw (two feet)	610 mm.
Length of dentary bone on lower border	342
Length of twelfth vertebra	71
Transverse diameter of ball	50
Length of twentieth vertebra	85
Length of humerus	146
Width of distal end	136
Length of radius	102
Length of ulna	88
Length of femur	141
Width of distal end	85
Length of fibula	117
Width of distal end	100
Length of tibia	99
Width of distal end	76

This specimen was found by myself in the yellow chalk of Butte creek, Kansas, in the summer of 1877.

The estimate of the length is clearly too great. If the proportions are as in the species of *Platecarpus* it would not be over sixteen feet in length. The vertebræ do not vary a great deal in length to the base of the tail, or about the thirtieth vertebra.

The average length of these, according to the measurements, is about three inches each, making ninety inches. The bones of the tail decrease in length rapidly in the tail, the length of the entire tail never being as great as the trunk in front of it. Sixteen feet, it is thus seen, is a large estimate of its length. If the specimen is greater than that, the proportions would furnish sufficient generic difference from *Platecarpus*. The type specimen is now on exhibition in the Yale Museum, and it will be an easy matter to determine the characters.

Cope has believed that this genus is identical with *Sironectes*. The last genus, if genus it be, differs from *Platecarpus* in the functional zygosphenes. If *Holosaurus abruptus* has such zygosphenes, and it is not at all improbable that it may, the synonymy would be extremely probable. It is thus not at all impossible that *Clidastes planifrons* Cope, *Sironectes anguliferus* Cope, and *Holosaurus abruptus* Marsh, are all identical.

Phosphorosaurus.

Phosphorosarus Dollo, Mem. Soc. Belg. Geol., III, 280, 1889.

Suprastapedial process of quadrate much elongated and united below with the infrastapedial process, inclosing an elongated auditory meatus; tympanic cavity extended and shallow. Frontal bone very narrow, with nearly parallel sides, and forming a part of the superior border of the orbits. Parietal bone small, with a triangular superior surface and a very large pineal foramen, bordering upon the frontal. Prefrontal not projecting into a horizontal plate. Type species, *P. ortliebii* Dollo, Brown Phosphatic Chalk, of Mesvin, Belgium.

Although this genus is yet incompletely known, the parts now known present very distinct and important differences from the corresponding ones of any other known genera. The genus is, seemingly, one of the most singular yet described, and further knowledge concerning it will be looked for with much interest. Just what are its nearest relationships, one cannot now say, but I believe that it will be found to be a member of the Platecarpinæ.

MOSASAURINÆ.

Mosasaurinæ Williston, Kans. Univ. Quart., VI, A, 181, 1897.

Hind limbs tetradactylate. Carpus and tarsus fully ossified, and with not more than six phalanges in any digit. Trunk relatively long, the thorax short, the tail much compressed distally, the chevrons coossified wth the centra. Zygosphenes rudimentary or functional. Humerus with a strong radial process at the distal end. Prefrontal more or less dilated into a horizontal plate posteriorly. Coronoid large, articulating with splenial on the inner side. Rostrum short, obtusely conical. Quadrate small, with a suprastapedial process of moderate length.

Mosasaurus.

Mosasaurus Conybeare, in Parkinson, An Introduction to the Study of Fossil Organic Remains, 198, 1822.[59]

Zygophenes rudimentary or wanting.

This character, slight as it is, seems to be the only one that is applicable for the differentiation of the species from those of *Clidastes*. Possibly future knowledge of the forms now known as *Mosasaurus* may determine other characters that will be of generic value either in the separation of this, or for the erection of others. The genus includes the largest of the known Mosasaurs, while those of *Clidastes* are either very small or of moderate size.

Clidastes.

Clidastes Cope, Proc. Acad. Nat. Sci. Phil., 1868, p. 233.
Edestosaurus Marsh, Amer. Journ. Sci., I, p. 417, June, 1871.

Small to medium sized, elongated, and slender. Premaxillary short, projecting but little beyond the teeth, obtusely conical. Teeth faceted upon the outer side, smooth on the inner, or smooth throughout; fifteen or sixteen in number in the maxillæ, seventeen or eighteen in the dentary, and twelve to fifteen in the pterygoids. Nares moderately dilated, situated anteriorly. Frontal not emarginated in the middle posteriorly. Pineal

59. "Mosasaurus, the Saurus of the Meuse, the Maestricht animal of Cuvier. As Cuvier has not yet given it a name, this name is suggested by Mr. Conybeare until he has done so."

foramen of moderate size, situated within the parietal bone. Facial surface of parietal elongate, the sides nearly parallel, emarginate posteriorly. Quadrate relatively small, the suprastapedial process reaching to about the middle of the bone. Expanded portion of the palatine elongate. Vertebræ with functional zygosphenes. Vertebræ from 117 to probably not more than 125 in number. Thoracic vertebræ eleven or twelve, lumbo-dorsals twenty-four or more, pygal caudals seven. Chevrons long, coossified with the centra. Tail much compressed, the spines elongated posteriorly. Limbs small; arm and leg bones short and expanded. Phalanges not more than six in number in any digit. Fifth finger divaricate and shorter than the fourth. Hallux rudimentary or wanting. Hind limb much smaller than the anterior one. Coracoid emarginate or entire. Ischium but little expanded distally, pubis with a proximal anterior process.

These characters are based upon a nearly complete specimen of *C. velox* and the larger part of one of *C. tortor*. The complete tail is known only in *C. velox*, and hence it is possible that the dilatation may not be present in other species.

The genus *Clidastes*, as first described by Cope, was based upon two dorsal vertebræ of *C. iguanavus*, the type species, from New Jersey. Shortly afterward, however, he gave a full generic description, as derived from an unusually good specimen of an allied species, *C. propython*, from Alabama. Only a little later, Marsh described a genus, which he called *Edestosaurus*, from Kansas, but without giving any really distinctive characters from *Clidastes*. The genus *Edestosaurus* has now been rejected by all writers on the Mosasaurs, save its author. It seems hardly necessary to point out the identity. The only distinctive character the author gave for his genus was the insertion of the pterygoid teeth, and even this character he modified later—"Palatine [*sic*] teeth more or less pleurodont."[60]

The genus is certainly very closely allied to *Mosasaurus*, but, I believe, shows sufficient distinctive differences to justify its existence. The form of the animal is elongated, as in that

60. American Journ. Sci., III, June, 1872.

genus, the paddles are of the same structure, and the skull shows very strong resemblances. The presence of functional zygosphenes will at once distinguish the known species.

Three species of *Clidastes* have been described from other regions than Kansas: *C. iguanavus* Cope, from New Jersey; *C. propython* Cope, from New Jersey; and *C. intermedius* Leidy, from the Rotten Limestone of Alabama. Only *C. propython* is well known of these, and a comparison of the published figures and descriptions by Cope (Extinct Batrachia, etc.) will convince one of the very strong relationships with *C. tortor*, especially from Kansas. Indeed, I half suspect that a careful comparison of the specimens may reveal the identity of the species. A specimen discovered some time ago at Flagler, Colo., which I have examined, probably from the Fort Pierre, may indicate another species.

Clidastes stenops.

Edestosaurus stenops Cope, Proc. Amer. Phil. Soc., 1871, p. 330; Marsh, Amer. Journ. Sci., III, p. 264, June, 1872.

Clidastes stenops Cope, Cret. Vert., etc., pp. 133, 266, pl. XIV, ff. 4, 5; XVII, ff. 7, 8; XVIII, ff. 1, 5; XXXVI, f. 3; XXXVIII, f. 3.

This species is very peculiar in lacking the expansion of the prefrontal over the orbit anteriorly, its shape being more nearly as it is in *Platecarpus*. In all other respects, however, it is true *Clidastes*. "The prefrontal is of peculiar form, and displays the greatest difference from that of *C. tortor*. Instead of being a horizontal bone, it is so oblique as to be nearly vertical. From this follows an alteration of the relation of all the parts. The squamosal suture with the frontal, which is marked by peculiar concentric rugosities in both species of this genus, instead of being on the upper, is nearly on the under surface, though oblique to both. The lateral margin is subinferior and plicate; the crest of the inner side bounding the maxillary projects far below it in front. The characters are similar to those of *C. tortor;* but all the bones are more massive, though of the same dimensions."

Nothing is known of the extremities.

Clidastes cineriarum.

Clidastes cineriarum Cope, Proc. Amer. Phil. Soc. 1870, p. 583. Cret. Vert. etc., pp. 137, 266; pl. xxi, ff. 14–17. Bull. U. S. Geol. Surv., Hayden, iii, p. 583.

"The type specimen of this species consists of vertebræ and pterygoid teeth. There are two anterior dorsals, three lumbars [pygals] and one caudal. The articular faces of the caudals are broad vertical ovals." This practically is all that is given to distinguish the species, a character that is more or less illusory and unsatisfactory, and in this present case wholly insufficient. "The centrum of the anterior dorsal is much compressed." Collected by Professor Mudge, six miles south of Sheridan.

Clidastes velox.

Edestosaurus velox Marsh, Amer. Journ. Sci., i, p. 450, June, 1871.
Edestosaurus pumilus Marsh, l. c., p. 452.
Clidastes affinis Leidy, Rep. U. S. Geol. Surv., Hayden, p. 283, 1873.
Edestosaurus dispar Marsh, Amer. Journ. Sci., xxix, pl. i, Jan. 1880.
Clidastes velox Williston and Case, Kans. Univ. Quart., i, 15, pls. ii, iii, 1892. Williston, Kans. Univ. Quart., ii, p. 83, pl. iii. Merriam, Ueber die Pyth., etc., p. 31, pl. iii.

This species has been used in the foregoing pages as typical of the genus, and a description of the different parts is given in detail, as based upon an unusually perfect skeleton discovered by myself in the summer of 1891 and now mounted in the museum. See plate lxii.

The diagnostic characters of the species are found in the structure of the quadrate, as described on a preceding page, in the emarginate coracoid, and in the structure of the front paddles, especially the forearm and carpal bones.

Marsh has figured a specimen of *Clidastes* with emarginate coracoid under the name of *C. dispar*, but, from my memory of the specimen, which was collected by myself, I am quite sure that he was wrong in its determination. The quadrates of the two species are readily distinguishable, and the figure of the type of *C. dispar* shows that it cannot possibly be the same as this. Cope expressed the opinion to me that the presence or absence of an emargination in the coracoid is

sufficient for generic separation. I am not inclined to agree with him, in the absence of other important differences. Should it be deemed sufficient, however, the name *Edestosaurus* cannot be used for this genus to include *C. velox*, since *C. dispar* is the type of *Edestosaurus*.

Of the identity of *C. affinis* Leidy, I have no doubt. The figures and descriptions given by Leidy agree perfectly, except that he describes the back teeth of *C. affinis* as having the enamel strongly striated, with the surface presenting evidences of subdivision into narrow planes. The differences from the actual condition of our specimens in this particular are so slight that I do not think the character has any weight.

In the paper cited above, Williston and Case expressed the opinion that *C. pumilus* Marsh is identical with *C. velox*. Merriam, who has examined specimens since then, would accept the species as distinct. "*C. pumilus* Marsh, zeichnet sich besonders durch seine geringe Grösse aus, welcher Eigenschaft wohl einer specifischer Werth beizulegen ist, weil man sonst annehmen müsste, das Individuen mit der geringen Schädellänge von 22 cm. zu derselben Species gehören wie die grossen Exemplare von *C. velox*."[61]

Nevertheless, it is a question of considerable moment how much specific weight can be placed upon size alone. Not a single character given by Marsh (the structure of the quadrate, basioccipital, etc.) is constant for the species. The only difference is size, so far as I can ascertain, after the most careful scrutiny of the various specimens in the museum. Possibly the jaws are more slender, and the articulation more oblique, but, if so, there must be other species which are intermediate in these characters, yet unnamed. Leidy (l. c., *supra*) expressed his views of the specific value of size as follows: "It is a question of some importance how far difference in size among the Mosasauroids may be a test of difference of species. Among the numerous remains of these animals which have been discovered, I have never yet observed any which presented any

61. Paleontographica, Ueber die Pythonomorphen, etc., XLI, 35.

relative to age. . . . In this view of the case, some of the many species of Mosasauroids may have been founded on different ages of the same."

This statement I can corroborate. I have seen altogether not far from 2000 specimens of Mosasaurs, and have collected with my own hands not less than 400. But I have never seen one that could unhesitatingly be pronounced to be that of a young animal. And certainly the Mosasaurs did not all die of old age. One suspects the youth in some cases from the distorted condition of the bones, due probably to less well-ossified conditions. The neural sutures are never found unclosed, and rarely do we find the bones of the skull macerated and separated. It is certain, then, that size cannot have a very great specific value.

The smallest specimen of a Mosasaur in our collection has the mandibles 250 mm. in length; that is, indicating an animal a little over six feet in length. These mandibles are more slender than are those of the specimen of *C. velox* used for description, but no more slender than in another specimen of larger size that should be referred to *C. velox*. In this specimen the jaws have a length of 365 mm. In the smallest specimen the coronoid projects much beyond the proximal end of the presplenial, while in all the other specimens the dentary projects much further back.

Marsh has given certain characters for the quadrate of *C. pumilus* which do not exist in the smallest specimen under examination. The quadrates in this specimen measure but thirty-three mm. in length, with the distal articular face twenty mm. in extent, precisely that of the type. The two quadrates agree exactly with those of the *velox* described in the foregoing pages, and *C. velox* has perhaps the most characteristic quadrate of any species of the genus. The inner face is not concave longitudinally on the anterior border, as it is in all those that I know of or that have been figured, but is nearly straight. The sharp ridge beginning just below and to the anterior side of the stapedial pit and extending towards or to the anterior inferior angle is present, and always wanting in the quadrate of the other species. Just anterior to the pit, on the border, there is a small

roughening, as in *C. velox*, and of which there is no sign in the specimens of other species at my command. The rugosity below the stapedial process is confined to the outer side, as in *velox*, and the length of the process is the same. The shape of the distal articular face presents no tangible differences. Furthermore, *C. velox* and the present are the only species of the genus now known in which the coracoid is emarginate; the two species agree in the paddles quite, and no two other species do. Finally, there are specimens in the museum which are intermediate in size between the two.

Taking all these facts into consideration, I am still of the opinion that there is but a single species.

Clidastes tortor.

Edestosaurus tortor Cope, Proc. Amer. Phil. Soc., Dec. 1871. Marsh, Amer. Journ. Sci., III, 264, April, 1872.

Clidastes tortor Cope, Cret. Vert., etc., pp. 48, 265, pls. IV, f. 1; XIV, f. 2; XVI, ff. 2, 3; XVII, f. 1; XIX, ff. 1–10; XXXVI, f. 3; XXXVII, f. 2. Bull. U. S. Geol. Surv. Hayden, III, p. 583. Williston and Case, Kans. Univ. Quart., I, 25.

Edestosaurus dispar Marsh, Amer. Journ. Sci., June, 1871; June, 1872, pl. I, ff. 1, 3.

Edestosaurus rex Marsh, *op. cit.*, June, 1872, pl. II, f. 1.

Clidastes medius Merriam, Ueber die Pyth. der Kans.-Kreide, 35.

The material referred to this species in the University of Kansas consists of one nearly complete skeleton and the incomplete remains of five others. The descriptions given are taken almost exclusively from the complete specimen, which was collected by the late Judge E. P. West. The species appears to be the most common of this genus in the Kansas chalk. I believe that I recognize three synonyms of the species in those previously described.

Edestosaurus dispar was the type of the genus. Its characters, both generic and specific, were given together, as is the custom of the author. The essential characters given by him, that is, those not common to other species, are as follows:

"In the cervical and anterior dorsals the cup and ball are somewhat inclined: in the posterior dorsals and lumbars [pygals] less so, and in the anterior caudals they are nearly,

but not quite vertical. The articular faces in the cervicals are a broad, transverse oval, faintly emarginate above for the neural canal. The quadrate has the same general form as in *C. propython*, but the external angle is situated further back, and has a notch in its posterior margin directly above the meatal pit. The posterior superior process is shorter, with a compressed free end. The teeth are curved and somewhat compressed. The enamel is smooth and shows faint indications of broad facets on the basal half. There were at least fifteen pterygoid teeth." In plate I, June, 1872, the author figures the coracoid, scapula, quadrate, and pelvis. The coracoid, though incomplete, shows the absence of the emargination, as in fact the author explicitly states ("There is certainly no emargination in the coracoid of *Clidastes*, *Edestosaurus*, and *Baptosaurus*, as specimens in the Yale museum conclusively prove"). It is true that Marsh in a later paper [62] figured a specimen with emarginate coracoid under the name of *Edestosaurus dispar*, but it is certain that his identification of his own species was wrong, since no species but *C. velox* (and *C. pumilus*) is yet known to have an emarginate coracoid. The specimen figured was collected and prepared by myself, and I have no hesitation in saying that the species is *C. velox*.

That the emargination was overlooked by the author seems strange, since he separated *Holosaurus* at the same time from *Platecarpus* (*Lestosaurus*) upon that very character. If this character is of generic value, then *C. velox* must receive a new name, since *E. dispar* is the type of *Edestosaurus*, and hence perfectly synonymous with *Clidastes*.

The paddles and quadrate agree quite with the corresponding bones of *C. tortor*. The notch in the margin of the upper border of the quadrate of *C. dispar*, upon which Marsh places much importance, is an individual character only, and of slight importance.

Edestosaurus rex, Marsh described essentially as follows:

"The skull is elongate, the frontal converging very regularly in front. The palatines have fourteen teeth. The shaft of the

62. American Journ. Sci., XIX, pl. I. f. 1, Jan. 1880.

ilium is less sigmoid than in *E. dispar*, and the ischium more expanded distally. The pubis appears to have had a more prominent anterior process. The articular ends of the anterior caudals are vertically oval."

The species differs, according to the author, from *C. tortor* and *E. dispar*, in "the less number of the pterygoid teeth and in other characters." The absence of one tooth in the pterygoids is not of specific importance. If the other characters had been of any importance the author would have stated them. The shape of the pelvic bones, by reference to his figures, one will see to be of trivial importance, and all might easily have been the result of imperfect preservation. Until these "other characters" are forthcoming, it will be quite safe to consider *C. rex* as a synonym of *C. tortor*.

Clidastes medius Merriam was based upon the shape of the prefrontal bone. "Die meisten knochen stimmen mit den entsprechenden von *C. velox* und *C. tortor* überein," but the prefrontal "nicht so weit in der Entwickelung zu einer einfachen horizontal Platte vorgeschritten ist."

In the absence of further differences and figures, I think it may be safely assumed that the difference of the prefrontal bone has been due to imperfect preservation rather than to a specific structure.

Clidastes wymani.

Clidastes wymani Marsh, Amer. Journ. Sci., June, 1872, plate II, f. 1.

This species was based upon two specimens — one including the chevron caudal vertebræ; the other, parts of the skull and anterior vertebræ. It is, of course, not at all certain that the two skeletons belonged to the same species.

"The specimens indicate a small reptile, very near *C. propython* in size, but differing from that reptile in several important particulars. One of the most noticeable of these is the form of the muzzle, which in the present specimen has a short and obtuse extremity, not unlike that of *Liodon proriger* Cope (*Tylosaurus*). The basioccipital has the condyle deep vertically, and only a shallow groove on the upper surface for the neural canal. The quadrate has the postero-superior process free at its lower ex-

tremity. Just below this there is a prominent rugose knob, with a deep pit under it entering from the external border.

"In the cervical vertebræ, the outline of the articular faces is transverse cordate, the ball of the axis showing a marked difference in this respect from that of *C. propython*, where it is subpentagonal. The centra of the anterior dorsals are elongate, and much constricted behind the diapophyses. The cup here becomes broader, and the emargination deeper. In the anterior caudals the articular faces are a broad vertical oval. There are eighty-one caudal vertebræ preserved, the last fifty being continuous. The terminal ones are less than one-twelfth of an inch in transverse diameter.

Measurements.

"Length of axis with odontoid process	39 mm.
Width between diapophyses	35
Length of sixth cervical without ball	27
Width of cup	18
Distance from end of muzzle to center of first tooth	12

North Fork of Smoky river."

Clidastes liodontus.

Clidastes liodontus Merriam, Ueber die Pyth. der. Kans.-Kreide, Pal., XLI, p. 35, 1895.

"This species is represented in the Munich collection by the nearly complete, though very fragmentary upper jaw, premaxillary, and dentary. The premaxillary is drawn out into a sharp point and possesses four teeth, which are rounded at their base and which show anteriorly a tolerably strong, on the distal third of the outer side a very weak carina. The maxillæ have the border for the premaxillary oblique as far as the fifth tooth. The maxillary teeth, like those of the dentary, are rounded at the base and compressed toward the apex, with a strong carina anteriorly and a somewhat lateral one posteriorly. Toward the hind end of the jaw the teeth are more strongly compressed and at the end strongly so. All the teeth are quite smooth, and may be compared with those of *Liodon* Owen, from which they are scarcely or not at all different."

The teeth are unknown in *C. cineriarum* and *C. westii*, either of which may be the same.

Clidastes westii.

Clidastes westii Williston and Case, Kans. Univ. Quart., I, p. 29, 1892.

The specimen upon which this species was based consists of a complete lower jaw, quadrate, fragments of the skull, the larger part of the vertebral column, and the incomplete hind and fore paddles. The vertebræ preserved are in two series, the one, numbering thirty-three, continuous with the skull; the other, sixty-three in number, all chevron caudals. The terminal caudals preserved indicate that there were several more in life, perhaps eight or ten; the first of the series was evidently among the first of those which bore chevrons. Altogether, the tail may have had seventy-five chevron caudals. The length of the two series are respectively seventy-one and seventy-two inches. Assuming that there was the same number of precaudal vertebræ as in *Clidastes velox*, the entire vertebral column would have measured in life fifteen feet and four inches. The lower jaw shows the skull to have been very nearly twenty-four inches in length, giving a total length for the animal when alive of seventeen and one-half feet. It is thus seen that the species is one of the largest of the genus.

While the skeleton was only about one-half longer than that of *C. velox* described in the foregoing pages, or of about the same length as a very complete specimen of *C. tortor* in the museum collection, the proportions of the animal were very much stouter. The figures given in plate LIII of the twenty-fifth, or eighteenth dorsal, vertebra will show the proportions between length and breadth. It is upon these remarkably stout proportions, and the shape of the articular faces as indicated by the figures and the measurements appended, that the species is chiefly distinguished from those previously known. The articular surfaces of the basal caudal vertebræ are remarkably triangular in shape, with the angles rounded and the sides of nearly equal length. This triangular shape is persistent for the first twenty of the series as they are preserved. The paddles, as shown in plates XXXV and XXXVI, show much stouter proportions than in any other known species.

The coracoid is rather more transversely expanded than in *C. velox*, with the posterior border more convex. There is no emargination whatever. The scapula is not unlike that of *C. velox*. The humerus differs slightly only in that the radial border is more nearly the length of the ulnar, and that the distal facets for the radius and ulna are more obliquely placed to each other. The radius is very distinctly different in the much shorter free outer border, which is shorter than the articular surface of the proximal articular surface. The articulation for the radius is placed less obliquely to the long axis and more nearly at right angles to the outer cartilaginous border, which is here less convex and more nearly parallel to the long axis of the bone. The ulna shows only slight differences; on the outer side of the distal articular surface there is a distinct facet for the medial carpal, wanting in *C. velox*.

Of the carpals, the radial is broader on its outer side, removing the first metacarpal further from the radius. Its proximal inner angle is not at all emarginate to help form the free border between the radius and ulna. The medial is rather broader from side to side, the free border more concave and extending from the radius to the ulna; on the inner side the bone articulates for a short distance with the ulna, which is not at all the case in *C. velox*. The ulnare and the bones of the distal row resemble those of *C. velox* closely. Of the metacarpals the fourth is peculiar in having the proximal inner angle much produced, so that the proximal articular surface is sinuous, and very oblique to the long axis of the bone.

Measurements.

Length of dentary	400 mm.
Depth opposite the first tooth	20
Depth opposite last tooth	62
Entire extent of mandible	630
Greatest depth at coronoid process	95
Length of axis with odontoid process	80
Length of axis without odontoid process	70
Vertical diameter of ball	24
Transverse diameter of ball	33
Length of fourth cervical vertebra to rim of ball	49
Expanse of diapophyses	82

Length of fifth cervical to rim of ball	49 mm.
Transverse diameter of ball	35
Expanse of diapophyses	90
Length of fourteenth vertebra to rim of ball	54
Transverse diameter of ball	40
Vertical diameter of ball	33
Length of eighteenth vertebra to rim of ball	50
Transverse diameter of ball	40
Vertical diameter of ball	36
Length of thirtieth vertebra to rim of ball	54
Transverse diameter of ball	46
Length of quadrate	65
Length of humerus	92
Length of radius	68
Length of ulna	65
Length of femur	95
Length of tibia	70

The specimen upon which this species is based was collected by Chas. Sternberg, from near McAllaster, in the Fort Pierre.

GENUS INCERTÆ SEDIS.

Baptosaurus.

Halisaurus Marsh, Amer. Journ. Sci., XLIII, Nov. 1869 (preoc.)
Baptosaurus Marsh, Proc. Phil. Acad., XXIII, Jan. 1870.

This genus was based upon a New Jersey species, represented "by a posterior cervical and an anterior dorsal vertebra; the right splenial bone with its concave articular face, and a small portion of the base of the skull." Another species (*H. fraternus* Marsh) from the same region was established on an anterior dorsal and two posterior dorsal vertebræ, found not far from each other, and probably part of the same series." The characters given for the type species (*H. platyspondylus* Marsh) are as follows: "This species is especially characterized by the great depression of the centra of the vertebræ, which gives the articular ball and cup a very transverse elliptical outline, exceeding in this respect apparently those of any other reptile. The vertebræ, so far as known, are also elongate, and without the zygosphenal and zygantral articulation." The coossification of the cervical hypapophyses is also given as a distinctive character.

Baptosaurus onchognathus.

Baptosaurus onchognathus Merriam, Ueber die Pyth. der Kans.-Kreide, 36, 1894.

"Among the material collected by Mr. Sternberg there was, in one of the boxes, some vertebræ and parts of a skull of like appearance. They belong, apparently, to the same individual. The single fragment of a jaw [pl. xxv, f. 6, after Merriam] agrees, except the abnormal articular, with *Platecarpus* or *Tylosaurus*, distinct, however, in that the upper border of the articular, immediately behind the cotylus, instead of being directed downwardly at an angle of about forty degrees, is turned vertically upwards into a high process, from which the hind end of the lower jaw has a hook-like appearance. Also at the posterior inferior angle, where in *Platecarpus* and *Tylosaurus* there is an elongated thickening, the border is thickened suddenly to more than twice the thickness behind this place, and then becomes suddenly thinner below the posterior end of the cotylus. There is a much crushed quadrate present, which possesses a supracolumellar [suprastapedial] process very much like that of *Platecarpus*." In a note he says: "Since the completion of the manuscript I have seen the original of Professor Marsh's *Baptosaurus*, and am convinced that the remains in the Munich museum really belong to the genus *Baptosaurus*." See, also, pl. xli, f. 3.

The lower jaw is so extraordinary that there will be no trouble in referring a similar structure to the same genus, notwithstanding the absence of other information concerning the species. The type species appears to have been much distorted from pressure, which may render the specific recognition somewhat difficult.

The absence of all information concerning the genus, except, practically, what is given above, prevents much if anything being said about its proper position. The types of the genus are from a much higher horizon than the Kansas species (which may be, however, from the Pierre) and it would be remarkable if the genus should be found to really occur in both places. It would seem strange that, in all the many hun-

dreds of specimens of Mosasaurs taken from the Kansas chalk previously and since, no other specimen has been found, I believe, that can be referred to this genus. The species remains as a problem which I fear will not be fully solved soon.

RESTORATION OF THE KANSAS MOSASAURS.

In plate LXXII are given restorations of the three well-defined types of Mosasaurs from the Kansas Niobrara Cretaceous—*Clidastes*, *Platecarpus* and *Tylosaurus*. They are based exclusively upon the material in the University of Kansas museum, and have been drawn with the greatest care. But very little about them is in any ways conjectural.

Clidastes is restored from a single specimen, discovered by myself on Butte creek, in Logan county, in the summer of 1891. It is, I believe, the most perfect specimen of a Mosasaur in any museum of the world. Another specimen, nearly as complete, of *Clidastes tortor*, collected by the late E. P. West two or three years previously, has offered some suggestions in the arrangement of the bones. The specimen of *C. velox* lacks some of the terminal phalanges of the front paddle, and many of the hind paddle; it is, therefore, not certain that these parts are correct in all details. That there could have been many more or less phalanges than what are figured, is impossible, since the ones preserved largely determine the number that are missing.

Platecarpus is based chiefly upon a single specimen, comprising the nearly complete disarticulated skull and a connected series of the vertebræ to beyond the middle of the tail, the sixty-fifth, together with the pectoral and pelvic girdles and many of the bones of the limbs. All the limb bones are present in other specimens of the same species. The position of the digits of the front paddle has been determined by the paddle of *P. ictericus* figured in plate XLIV; that of the hind paddle by the figure given by Marsh.[63] As in *Clidastes*, some of the digits may have

63. American Journ. Sci.

had a few phalanges more or less, but certainly not enough to perceptibly modify the general form. The only parts conjectural in the restoration are the number of the thoracic ribs and the precise number of the caudal vertebræ with chevrons. There are no characters present in this or any other genus by which the number of thoracic ribs may be determined save by their actual preservation *in situ*. That they were materially different from what is figured, is impossible, since many of the short ribs are preserved in some of the specimens. Isolated caudal vertebræ and partly connected series are present in other specimens, from which it is evident that the tail agrees in its general characters well with that of *Tylosaurus*. They may have been a few more or less of the small vertebræ, but certainly not enough to perceptibly modify the length in the restoration.

Tylosaurus is based almost wholly upon three specimens in the museum, one with the posterior part of the head and the absolutely complete series of vertebræ, connected from head to tip of tail, collected by E. P. West; the second, with the skull and cervical vertebræ equally complete, obtained from Mr. H. T. Martin; the third, with the paddles nearly complete, together with many ribs and vertebræ. This last specimen is the one collected by Professor Snow, in which the skin is preserved as figured in plate LXX.

Each of the three animals thus restored has its own peculiar characters, representing three distinct types of the group, which I have already defined. The skull of *Platecarpus* is the broadest; that of *Tylosaurus* the slenderest. The jaw teeth are most numerous in *Clidastes;* the fewest and most powerful in *Platecarpus*. The pterygoid teeth, on the other hand, are the strongest in *Tylosaurus;* smallest and least effective in *Platecarpus*. Correlated with these dental peculiarities are the large size of the paddles in *Platecarpus*, and the small size in *Tylosaurus*. The skull of *Platecarpus* has a more rounded contour posteriorly, and the striking size of the quadrate is conspicuous.

In *Clidastes* the slenderness of the body, the shortened and small thorax, the much greater length of the lumbo-dorsal region, and the proportionally shorter tail are all noticeable. The

preterminal dilatation of the tail, together with the more elongate chevrons and their rigid coossification with the centra, all show a more powerful propelling organ than is the case with either of the other genera.

The differences in the paddles in the three genera are also conspicuous, those in *Platecarpus* being the largest, and those of *Tylosaurus* the smallest. The hind paddles in *Tylosaurus* are the largest and the least reduced. Hyperphalangy is carried to the greatest extent in *Tylosaurus*, where the fifth digit of the front paddle, also, is not at all reduced. On the other hand, the phalanges are least numerous in *Clidastes*. The flexibility is greatest in *Tylosaurus*, where mobility is obtained at the expense of strength. In *Clidastes* the opposite extreme is seen. In the one, control over the different movements through the water was due chiefly to the tail; in the other, to the limbs. In *Clidastes* the bones of the limbs are all closely articulated, and the tarsus and carpus are fully ossified. In the other genera, and especially in *Tylosaurus*, the limb bones had a greater amount of cartilage between them and the joints were correspondingly less well formed and less perfect. In *Clidastes* the ossification of the bones is more complete; their texture is finer and more solid, and the bones are less liable to distortion or compression.

Upon the whole, *Platecarpus* combined the greatest flexibility with the greatest strength, and was, for its size, the most powerful and most pugnacious of the Kansas Mosasaurs. In later geological times its prowess was doubtless contested by the species of *Mosasaurus* proper. In the Kansas seas, however, *Platecarpus ictericus* was, I believe, the king of the Mosasaurs, though neither the largest nor the most fleet in its movements.

In size, the maximum among the Kansas Mosasaurs was reached in *Tylosaurus dyspelor*, which may have attained a length of thirty-five feet, with a head measuring four feet in length. The smallest and most graceful of all was *Clidastes pumilus*, which had a length of about six feet. A few species larger than *T. dyspelor* are known from New Jersey, some possibly attaining

a length of thirty-seven or thirty-eight feet, and some species yet larger are, I believe, reported from Europe. I am confident, however, that there never has been a Mosasaur in existence — certainly none whose remains are now known — whose length was greater that forty-five feet. The text-books and popular descriptions place the length of these animals at from 75 to 100 feet.

The habits of the animals when alive are not hard to conjecture. They were marine lizards, living for the most part in shallow waters, though, often, especially the largest species, venturing far out to sea. That they did not usually frequent deep water, as did the Plesiosaurs, is probable. There are pebbles from the stomach of a Plesiosaur in the University museum which must have been brought to Kansas from hundreds of miles away — longer journeys than I believe the Mosasaurs ever made. Perhaps this fact will account for the entire absence, so far, of the Mosasaurs in the Benton rocks, while they do occur most abundantly in the shallower water deposits of the Niobrara in Kansas, especially towards the close of the epoch.

While the flexibility and loose union of the jaws doubtless permitted animals of considerable size to be swallowed, the structure of the pectoral girdle would never have permitted any such feats of deglutition of which the python and boa are capable. It has been supposed that the lower jaws were capable of an anterior prolongation in swallowing their prey, but such must have been very slight, since the union with the pterygoid is too firm to permit much, if any, motion here. In the pictures of the skull, the remarkable, though incomplete, ball-and-socket joint back of the middle of the jaw is conspicuous, differing in this respect from all other reptiles, ancient or modern. That there was any degree of vertical motion here is scarcely possible, since the union of the jaw above was too close. As has been described, a thin plate of bone passed across the joint and was ensheathed within the presplenial, permitting probably a small amount of lateral bending, but little or none of vertical. The animals living in the water, with no solid objects to aid in deglutition, the body not serpentine

enough to coil about the prey and hold while being forced down the gullet, and the limbs non-prehensile and small, it is seen that, without some peculiar modification of the jaws, food would have been swallowed with difficulty. This peculiar modification is seen in the structure of the joint in the jaws. It has been supposed that the prey, after seizure, was pulled down the throat by the alternate protrusion and fixing of the separated jaws. This, however, could not have been true. The mandibles in front, while not rigidly connected, yet show ligamentous union, and, as we have seen, the quadrates were largely fixed by the pterygoids posteriorly. The jaws, acting together, pulled the prey backward by the lateral bending at the articulation, and then both were disengaged after the upper jaw teeth and the pterygoid teeth had been inserted. Possibly a saurian of the largest size might have swallowed entire an animal as large as a two year-old-calf, but I doubt the possibility. Their food was evidently the numerous small fishes that swarmed the seas with them, with perhaps an occasional animal of their own kind. Possibly this will account for the fact that young Mosasurs are almost unknown as fossils.

"The habit of swallowing large bodies between the branches of the under jaw, necessitates the prolongation forward of the mouth of the gullet; hence, the throat in the Pythonomorpha must have been loose and almost as baggy as a pelican's. Next, the same habit must have compelled the forward position of the glottis or opening of the windpipe, which is always in front of the gullet. Hence these creatures must have uttered no other sound than a hiss, as do animals of the present day which have a similar structure, as, for instance, the snakes. Thirdly, the tongue must have been long and forked, and for this reason: its position was still anterior to the glottis, so that there was no space for it, except it were inclosed in a sheath beneath the windpipe when at rest, or thrown out beyond the jaws when in motion. Such is the arrangement in the nearest living forms, and it is always in these cases cylindrical and forked." The above, by Cope, was written under some misapprehensions of the true nature of these animals. Still I believe

that he was correct for the most part. The skin of the neck was not necessarily more bagged than that of *Varanus*, and the sounds uttered by the animals must have been practically such as are uttered by *Varanus*, since the structure of all the parts here was doubtless the same in both animals. *Varanus* has a long, forked tongue, and I do not doubt but that the Mosasaurs had such also.

The Mosasaurs must have been practically helpless on land. They were not sufficiently serpentine, especially *Tylosaurus* and *Platecarpus*, to move about on *terra firma* without the aid of limbs, and these were not at all fitted for land locomotion. That they may have frequented the beaches for the purpose of depositing their eggs is probable, though not certain. They were certainly not viviparous.

That they were pugnacious in the extreme is very evident from the many scars and mutilations which they suffered during life. I have observed exostosial growth in their lower jaws, the vertebræ, especially those of the tail, and the paddles, especially the digits. In some the mutilations have been extensive. One tail of a *Platecarpus* has the spines of the distal half of the tail broken off and false joints produced. Never have I known of a case where there has been evidence of ante-mortem loss of the tail, or any part of it. A paddle of another specimen, figured in part in plate LVI, has the bones of the forearm, carpus and metacarpals all united by exostosis.

Coprolites which I have always had reason to believe were from these animals are in some places very abundant, weighing from an ounce or two up to a half pound or more. They are ovoidal in shape, with sphincter or intestinal impressions upon them, and contain very comminuted parts of fish bones, fish scales, etc.

Whether or not they are Mosasaurian in origin, I doubt not that the food of the Mosasaurs consisted almost exclusively of fishes, living or dead, and such small animals as drifted upon the water. Their bones frequently bear the impression of teeth, of post-mortem origin, and in many cases I have found the teeth of small sharks imbedded in them. Invariably, after long ex-

perience, I have learned that a missing part of a specimen could never be found in the immediate vicinity. A distance of a single foot without a bone always means that no more of the skeleton may be found in extensive excavations.

And yet, some disturbances of the bones took place after falling to the bottom; vertebræ are dislocated and paddle bones almost always separated. The skull is always attached firmly to the vertebral column. When one finds a cervical vertebra joined to its mate, he may confidently expect that the head will be uncovered by further excavation.

Bones of the hind paddles are always much less common than those of the front, and such bones in position are among the greatest of rarities.

The animals were covered completely by a scaly skin, the scales in size and shape so closely resembling those of a large monitor that a further description is unnecessary. But a single specimen showing these scales is known, that of the *Tylosaurus* which has furnished the best paddles of the genus yet known. The specimen was discovered by Chancellor Snow many years ago on Hackberry creek in Gove county, and the large slab with the bones was safely transported to the museum. Plate LXIX is made from the electrotype originally used by Chancellor Snow in the description of the skin.[64] In plate LXX is given a reproduction from the photograph which was used in the production of the wood engraving. The two together will convey a most perfect idea of the skin. The impression, or rather the carbonized scales themselves, are from the anterior part of the body, from the region over or just back of the scapula.

In plate LXXI is given a restoration of *Clidastes velox* as it is believed it appeared in life, based upon all the evidences given in the foregoing pages. It is not possible that the picture can be very far from the real truth. Whether or not the animal had colorational markings, it is of course impossible to say, but that its shape was nearly like what the artist has depicted is fairly certain. Possibly the abdominal region was larger than is shown, but I believe not.

64. Transactions Kans. Acad. Sci., VI, 54.

The frontispiece, from a painting by Mr. J. Carter Beard, the well-known artist, has been for the most part based upon the restorations of the present volume, and others published elsewhere by myself. It is, I believe, as nearly correct as it is possible for such an ideal representation of extinct animals to be. The Petrodactyls and Plesiosaurs, not treated in the present volume, will be fully described and figured in the next one of this series, I trust. It is not at all probable that the saurians were often upon land, as they are represented, though possible.

EXPLANATION OF PLATES.

(Pages 223-347.)

The following abbreviations apply to all the plates of the skull:

Ang, angular.
Art, articular.
Bo, basioccipital.
Bs, basisphenoid.
Cor, coronoid.
Dn, dentary.
Eo, exoccipital.
Fr, frontal.
Jug, jugal.
L, lachrymal.
Max, maxilla.
Na, nares.
Oc, occipital condyle.
P, parietal.
Pal, palatine.
Pet, petrosal.
Pfr, prefrontal.
Pmx, premaxillary.
Po, postorbitofrontal.
Prs, prosquamosal.
Prsp, presplenial.
Ptg, pterygoid.
Q, quadrate.
S, squamosal.
So, supraoccipital.
Spl, splenial.
St, stapes.
Sur, surangular.
Tr, transverse.
V, vomer.

PLATE X.—Skull of *Clidastes velox* Marsh, from the side.

PLATE XI.—Skull of *Clidastes velox* Marsh, from above.

PLATE XII.—Skull of *Clidastes velox* Marsh, from below.

PLATE XIII.—Skull of *Platecarpus coryphæus* Cope, from the side.

PLATE XIV.—Skull of *Platecarpus coryphæus* Cope, from above.

PLATE XV.—Skull of *Platecarpus coryphæus* Cope, from below.

PLATE XVI.—Skull of *Tylosaurus proriger* Cope, from the side.

PLATE XVII.—Skull of *Tylosaurus proriger* Cope, from above.

PLATE XVIII.—Skull of *Tylosaurus proriger* Cope, from below.

PLATE XIX.—Skull of *Mosasaurus horridus* Williston, from the side.

PLATE XX.—Skull of *Mosasaurus horridus* Williston, from above.

PLATE XXI.—Skull of *Mosasaurus horridus* Williston, from below.

PLATE XXII.—Upper figure, maxilla and mandible of *Brachysaurus overtonii* Williston (the articular and splenial bones are shown from the inner side, the other bones from without); lower figure, left mandible of *Platecarpus coryphæus*, from the inner side.

PLATE XXIII.—Upper figure, left mandible of *Clidastes westii* Williston, from the outer side; lower figure, right mandible of *Clidastes tortor* Cope, from the inner side.

PLATE XXIV.—Fig. 1, right pterygoid of *Platecarpus coryphæus*, from below; fig. 2, premaxilla of same, from below; fig. 3, the same, from above; fig. 4, postorbitofrontal of same, from within; fig. 5, left jugal of same, from without; fig. 6, sternum of *Clidastes velox* Marsh, after Marsh; fig. 7, left quadrate of same, from without.

PLATE XXV.—Fig. 1, left maxilla of *Platecarpus coryphæus*, from without; fig. 2, the same, from within; fig. 3, prefrontal of same; figs. 4, 5, transverse bones of same; fig. 6, posterior part of mandible of *Baptosaurus onchognathus*, after Merriam.

PLATE XXVI.—*Platecarpus coryphæus.* Fig. 1, parietal, from above; fig. 2, frontal, from above; fig. 3. frontal, from below; fig. 4, left prosquamosal, from without.

PLATE XXVII.—Upper figure, posterior view of skull of *Platecarpus coryphæus;* fig. 1, radius of *Clidastes westii*, 1a, ulna; fig. 2, radius of *C. tortor*, 2a, ulna of same; figs. 3, 4, radii of *C. velox;* 3a, 4a, ulnæ of same.

PLATE XXVIII.—Fig. 1, quadrate of *Clidastes velox*, from within; fig. 2, the same, from without; fig. 3, the same, from in front; fig. 4, the same, from behind; fig. 5, pterygoid tooth of *Platecarpus coryphæus*, enlarged; fig. 6, mandibular tooth of *Clidastes tortor*, enlarged; fig. 7, mandibular tooth of *Platecarpus coryphæus*, enlarged; fig. 8, radius of *Platecarpus coryphæus.*

PLATE XXIX.—Fig. 1, mandibular tooth of *Tylosaurus proriger*, from within, showing socket of successional tooth, enlarged; fig. 2, posterior cervical vertebra of *Clidastes tortor*, from behind, showing zygantrum; fig. 3, sclerotic plates of *Platecarpus coryphæus*, enlarged; fig. 4, anterior end of vomer of *Platecarpus coryphæus*, from without, enlarged; fig. 5, undetermined bone of *Platecarpus coryphæus*, enlarged.

PLATE XXX.—*Brachysaurus overtoni.* Fig. 1, mandibular tooth, natural size; fig. 2, frontal bone, from above; fig. 3, left quadrate, from within; fig. 4, posterior cervical vertebra, from behind; 4a, the same from below; fig. 5, median caudal vertebra, from behind; fig. 6, humerus; fig. 7, undetermined paddle bone. Except fig. 1, one-half natural size.

PLATE XXXI.—Figs. 1, 2, 3, hyoid bone of *Platecarpus*, natural size, after Marsh; figs. 4, 5, pygal vertebra of *Platecarpus coryphæus*, from behind and from the side; fig. 6, coracoid and scapula of *Clidastes velox*, from behind; fig. 8, part of hind paddle of *Mosasaurus lemoinii*, after Dollo, much reduced. Other figures one-half natural size.

PLATE XXXII.—Left figure, part of left paddle of *Mosasasurus horridus*, one-third natural size: *h*, humerus; *R*, radius; *U*, ulna; *I*, first metacarpal; right figure, right quadrate of *Mosasaurus horridus*, from within, two-thirds natural size.

PLATE XXXIII.—Incomplete left front paddle of *Clidastes velox: C*, coracoid; *S*, scapula; *Hm*, humerus; *I*, first digit; *V*, fifth digit.

PLATE XXXIV.—Pelvis and part of left hind paddle of *Clidastes velox: Il*, ilium; *P*, pubis; *Is*, ischium; *F*, femur; *T*, tibia; *Fi*, fibula; *Ta*, tarsal *Imc*, first metatarsal. Three-fourths natural size.

PLATE XXXV.—Pectoral girdle and part of right front paddle of *Clidastes westii: S*, scapula; *C*, coracoid; *H*, humerus; *R*, radius; *U*, ulna; *I*, *II*, and *IV*, first, second and fourth metacarpals.

PLATE XXXVI.—Part of right hind paddle of *Clidastes westii:* femur, tibia, fibula, tarsals, and first metatarsal.

PLATE XXXVII.—Right scapula and coracoid of *Clidastes tortor*, from without: *S*, scapula; *C*, coracoid.

PLATE XXXVIII.—Part of left front paddle of *Clidastes tortor: h*, humerus; *r*, radius; *u*, ulna; *ue*, ulnare; *re*, radiale; *o*, third carpal of distal row; *Imc*, first metacarpal.

PLATE XXXIX.—Upper two figures: proximal and distal ends of humerus of *Clidastes westii;* right-hand figure, right pelvic bones of *Clidastes tortor*, the upper element the ilium, the lower right one the pubis, the lower left one the ischium; lower left-hand figure, the left pelvic bones of *Clidastes dispar* Marsh, after Marsh.

PLATE XL.—*Tylosaurus proriger.* Fig. 1, femur, from below; fig. 2, ilium; fig. 3, right ischium, from without; fig. 4, left ischium, from within; fig. 5, femur, from above; fig. 6, radius; fig. 7, metacarpal; fig. 8, ulna; fig. 9, radius; figs. 10 and 11, indeterminate bones of *Brachysaurus overtonii.*

PLATE XLI.—Fig. 1a, left ilium of *Tylosaurus proriger*, from without: 1b, pubis of same; 1c, ischium of same; fig. 2, pubis of *Platecarpus;* fig. 2a, ischium of same; fig. 3, posterior cervical vertebra of *Baptosaurus onchognathus*, from behind, after Dollo; fig. 4, posterior cervical vertebra of *T. dyspelor*, from behind; fig. 5, the same, from the side.

PLATE XLII.—Fig. 1, Pygal vertebra of *Tylosaurus dyspelor*, from behind; fig. 2, the same, of another specimen, from in front; figs. 3, 4, median dorsal vertebra of *Platecarpus coryphœus*, from the side and from behind; figs. 5, 6, posterior cervical vertebra of *Clidastes tortor*, from behind and from the side.

PLATE XLIII.—*Platecarpus ictericus: S*, scapula, from without; *C*, right coracoid, from without.

PLATE XLIV.—Right front paddle of *Platecarpus ictericus*, from above, after a drawing made *in situ* by the author: *H*, humerus; *R*, radius; *U*, ulna; *MC*, metacarpals; *I* and *II*, *III*, *IV*, *V*, first to fifth digits.

PLATE XLV.—Fig. 1, radius of *Platecarpus*, side and end views; fig. 2, tibia (?) of *Platecarpus*, side and end views; fig. 3, humerus of ? *Platecarpus crassartus*, after Cope; fig. 5, dorsal vertebra of same, from below; fig. 4, indeterminate paddle bone of same.

PLATE XLVI.—Left humerus of *Platecarpus coryphæus*, from below; fig. 2, distal end of same; fig. 3, the same, from above; fig. 4, proximal end of same; *s*, scapula of *Tylosaurus dyspelor*, from without; *c*, coracoid of same, from without; *s*, right scapula of *T. dyspelor*, from without; *c*, coracoid of same.

PLATE XLVII.—Left-hand figure, frontal bone of *Clydastes tortor*, from above; right-hand figure, right pelvic bones of *Platecarpus simmus*, after Marsh, from without: *a*, ilium; *b*, ischium; *c*, pubis; *d*, femur.

PLATE XLVIII.—Coracoid and front paddle of *T. proriger*, as imbedded in the chalk, the left-hand figure, outlines of the bones as determined from the two sides of the slab.

PLATE XLIX.—Left pelvic bones of *T. proriger*, as imbedded in the same slab as the preceding; the lower right element is the pubis; the left, the ischium.

PLATE L.—Hind paddle of *Tylosaurus proriger*, in matrix: *f*, femur; *f'*, fibula; *t*, tibia; *ta*, tarsal; *mc*, metatarsal; *Vm*, fifth metatarsal.

PLATE LI.—*Platecarpus coryphæus*, in matrix: fig. 1, right humerus, from below; fig. 2, left coracoid, from without; fig. 3, right scapula, from within; fig. 4, left humerus, from above; fig. 5, carpal; fig. 6, radius; fig. 7, cervical hypapophysis; figs. 8, 9, cervical ribs; figs. 10, 11, 12, thoracic ribs; fig. 13, cartilage.

PLATE LII.—*Platecarpus coryphæus:* fig. 1, left humerus, from below; fig. 2, ulna; fig. 3, right lateral piece of atlas, from within.

PLATE LIII.—Fig. 1, thirty-eighth vertebra of *Clidastes westii*, from behind; fig. 2, the same, from below.

PLATE LIV.—Pygal vertebræ, from behind: fig. 1, *Tylosaurus* sp., from Fort Pierre; figs. 2, 3, *Platecarpus coryphæus;* fig. 4, *Clidastes tortor;* fig. 5, anterior caudal vertebra of same.

PLATE LV.—Bones of *Tylosaurus proriger*, in matrix: fig. 1, radius; fig. 2, humerus; fig. 3, coracoid; fig. 4, cartilage.

PLATE LVI.—Figs. 1, 2, 4, femora of *Platecarpus coryphæus;* fig. 3, radius; fig. 5, radius, carpus, and part of metacarpus, showing exostosial growth.

PLATE LVII.—Figs. 1, 2, radii of *Platecarpus* sp.?; fig. 3, tibia of *Clidastes* sp.; fig. 4, tibia of *Platecarpus coryphæus;* fig. 5, fibula of same; fig. 6, metatarsal of same; fig. 7, fifth metatarsal of same; figs. 8, 9, 10, tarsals of same.

PLATE LVIII.—Figs. 1, 2, 3, radii of *Platecarpus coryphæus;* figs. 4, 5, 6, ulnæ of same; fig. 7, radial carpal of same; fig. 8, ulnar carpal of same; figs. 9, 10, distal carpals of same.

PLATE LIX.—*Tylosaurus dyspelor:* fig. 1, humerus; fig. 2, radius; fig. 3, ulna; figs. 4–8, metacarpals and phalanges.

PLATE LX.—Fig. 1, right quadrate of *Tylosaurus proriger*, from behind; fig. 2, left quadrate of same, from within; fig. 3, left quadrate of *Platecarpus coryphœus*, from without; fig. 4, right quadrate of *Clidastes westii*, from in front; fig. 5, right quadrate of *Clidastes tortor*, from without; fig. 6, right quadrate of *Clidastes velox*, from behind; fig. 7, left quadrate of same, from within.

PLATE LXI.—Figs. 1, 2, quadrates of *Tylosaurus dyspelor*, from without and within; fig. 3, right scapula of *Platecarpus coryphœus*, from without; fig. 4, left quadrate of *Clidastes tortor*, from within.

PLATE LXII.—Fig. 1, humerus of *Brachysaurus overtonii;* fig. 2, coracoid of same; fig. 3, skeleton of *Clidastes velox*, in matrix.

PLATE LXIII.—*Platecarpus coryphœus:* fig. 1, parietal bone, from below; fig. 2, petrosals, from behind; fig. 3, left jugal, from within; fig. 4, left prosquamosal, from within; fig. 5, odontoid; fig. 6, atlantar intercentrum; figs. 7, 8, lateral pieces of atlas, from within and without; fig. 9, coronoid; fig. 10, surangular, from within; fig. 11, articulo-angular, from within.

PLATE LXIV.—Fig. 1, left quadrate of *Clidastes tortor*, from behind; fig. 2, left quadrate of *Platecarpus coryphœus*, from without; anterior caudal vertebræ of *Platecarpus coryphœus*, in matrix; quadrates of same.

PLATE LXV.—Posterior thoracic and anterior dorsolumbal vertebræ and ribs of *Tylosaurus proriger*, in matrix.

PLATE LXVI.—Posterior caudal vertebræ of *Tylosaurus proriger*, in matrix.

PLATE LXVII.—Terminal caudal vertebræ of *Tylosaurus proriger*, in matrix, continuation of those in plate LXVI, the proximal ones showing ante-mortem injuries.

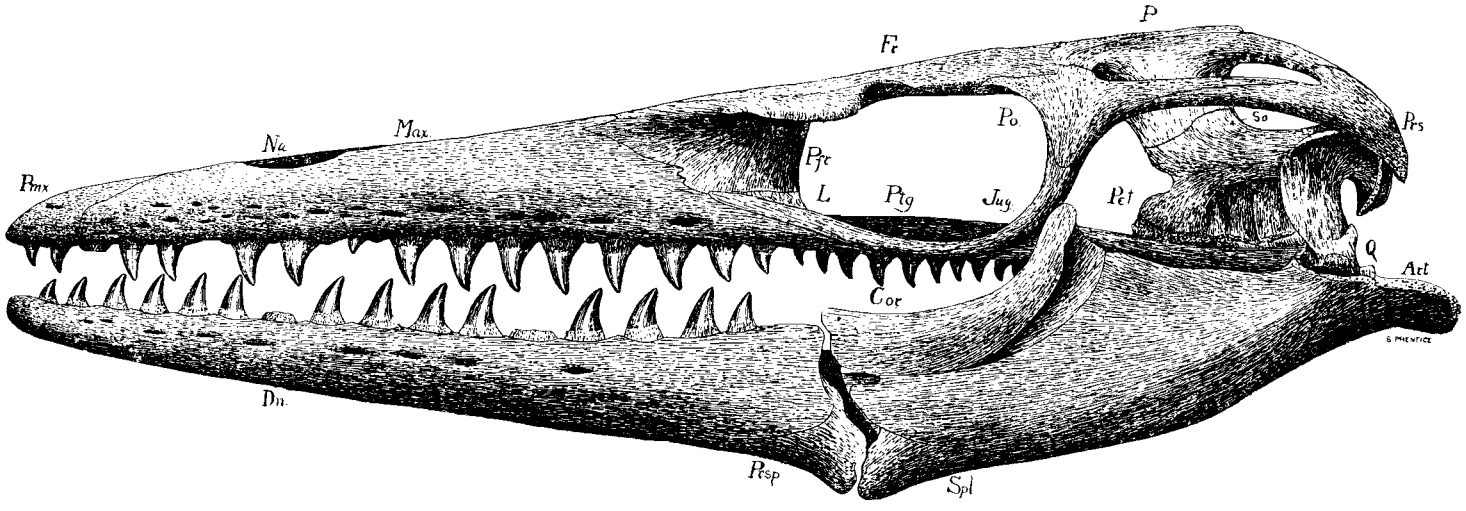
PLATE LXVIII.—Slab with specimen of *Tylosaurus proriger*, on which imprints of skin occur; the impressions are at the left side below the vertebræ and ribs.

PLATE LXIX.—Skin impression of *Tylosaurus proriger.*

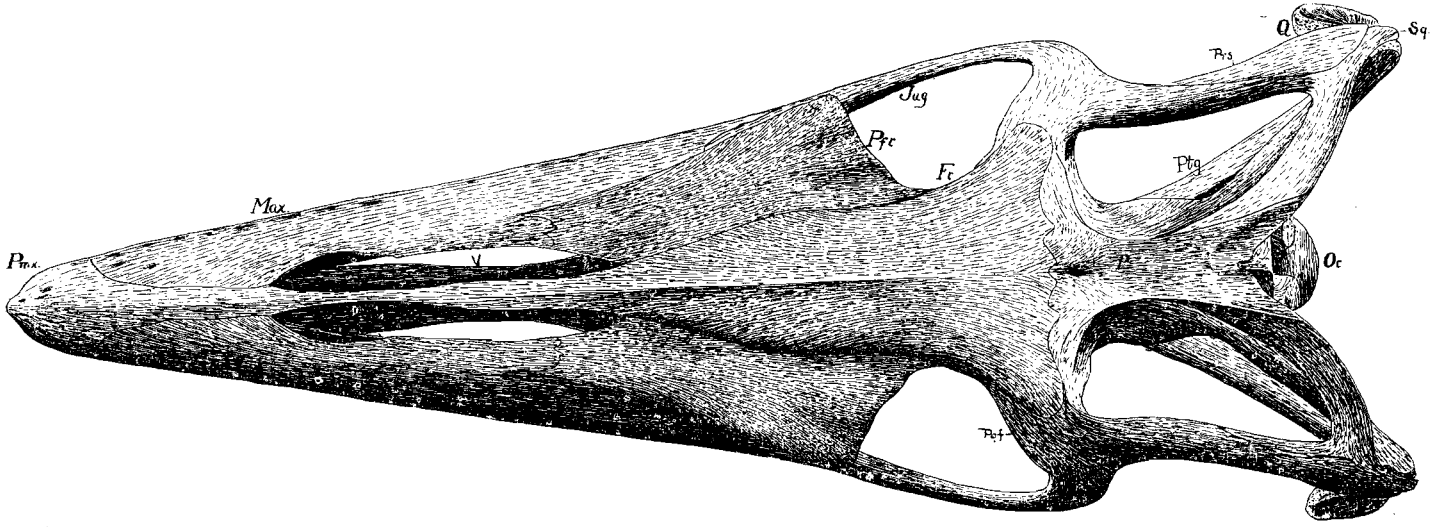
PLATE LXX.—Photographic reproduction of part of plate LXIX, reversed.

PLATE LXXI.—Restoration of *Clidastes velox*, as in life, the middle figure; restoration of *Uintacrinus socialis* at left; restoration of *Ornithostoma ingens* at right.

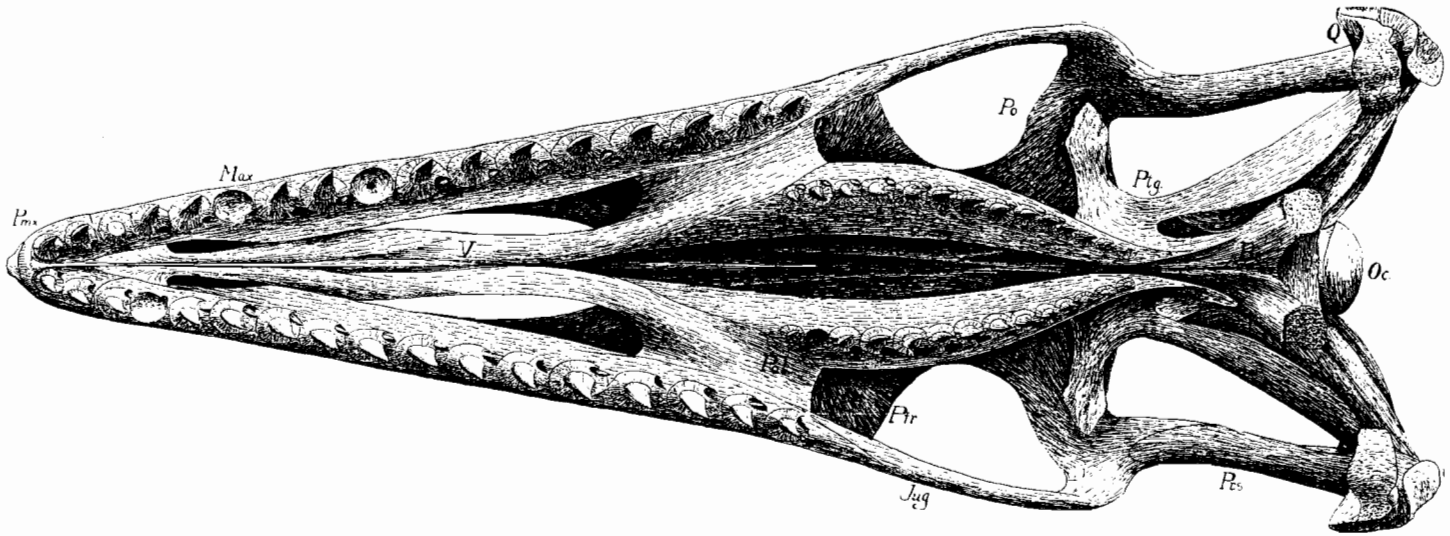
PLATE LXXII.—Restoration of the skeletons of Kansas Mosasaurs: fig. 1, *Clidastes velox*; fig. 2, *Platecarpus coryphœus*; fig. 3, *Tylosaurus proriger.*



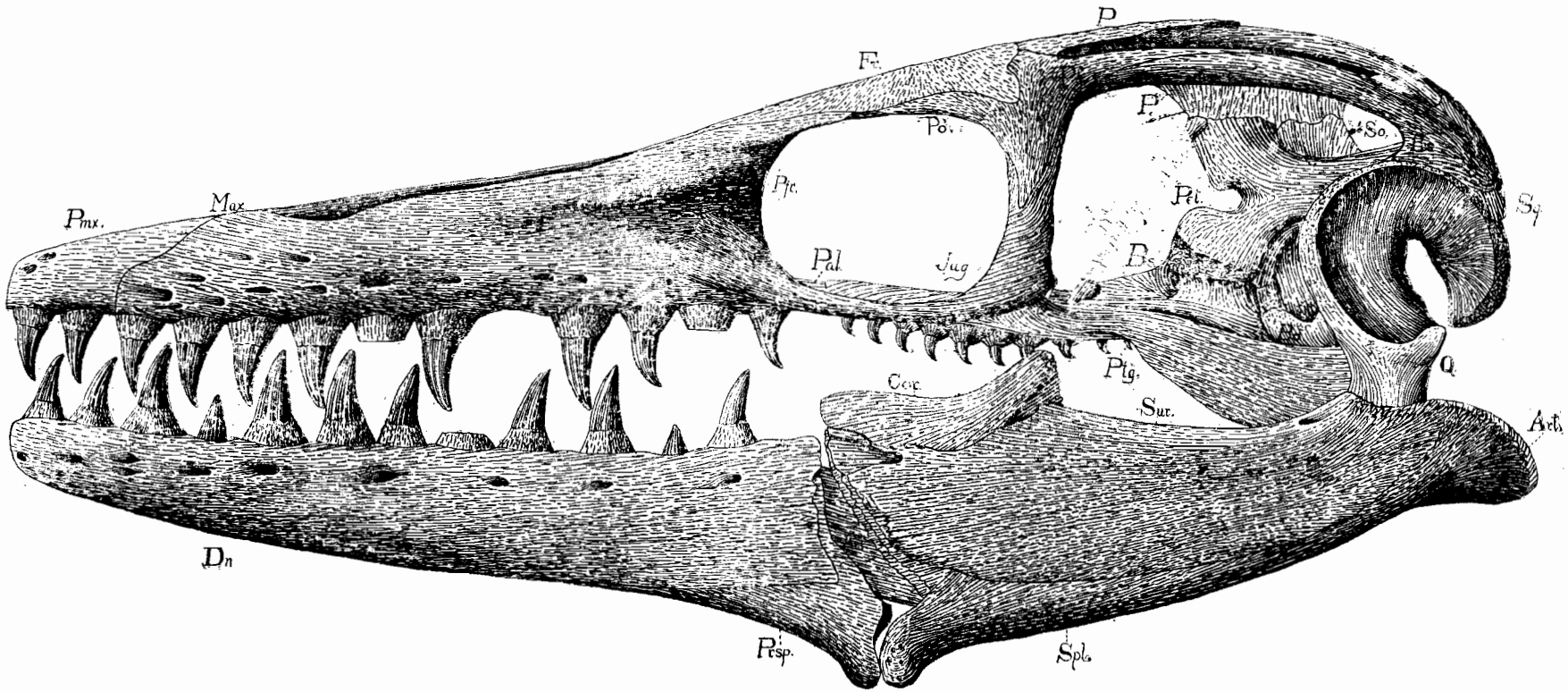
CLIDASTES VELOX MARSH, × three-eighths.



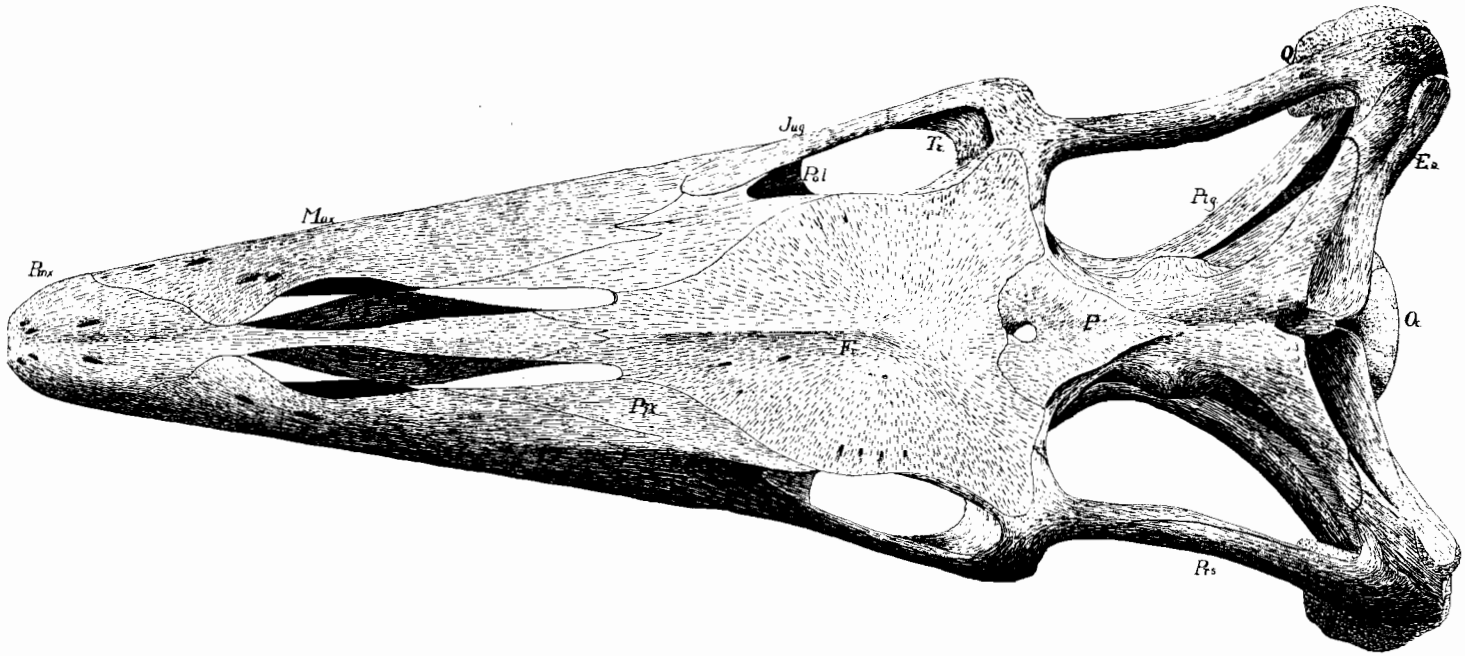
CLIDASTES VELOX (from above), × three-eighths.



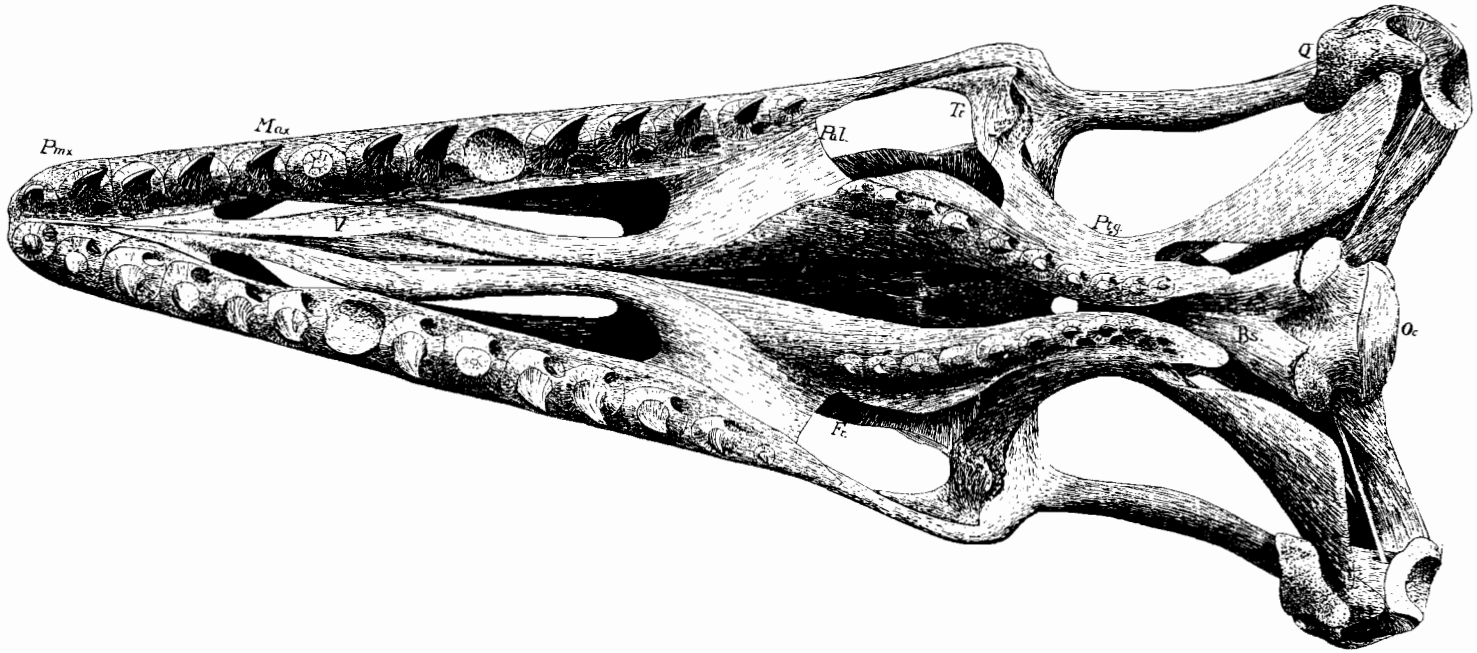
CLIDASTES VELOX (from below), × three eighths.



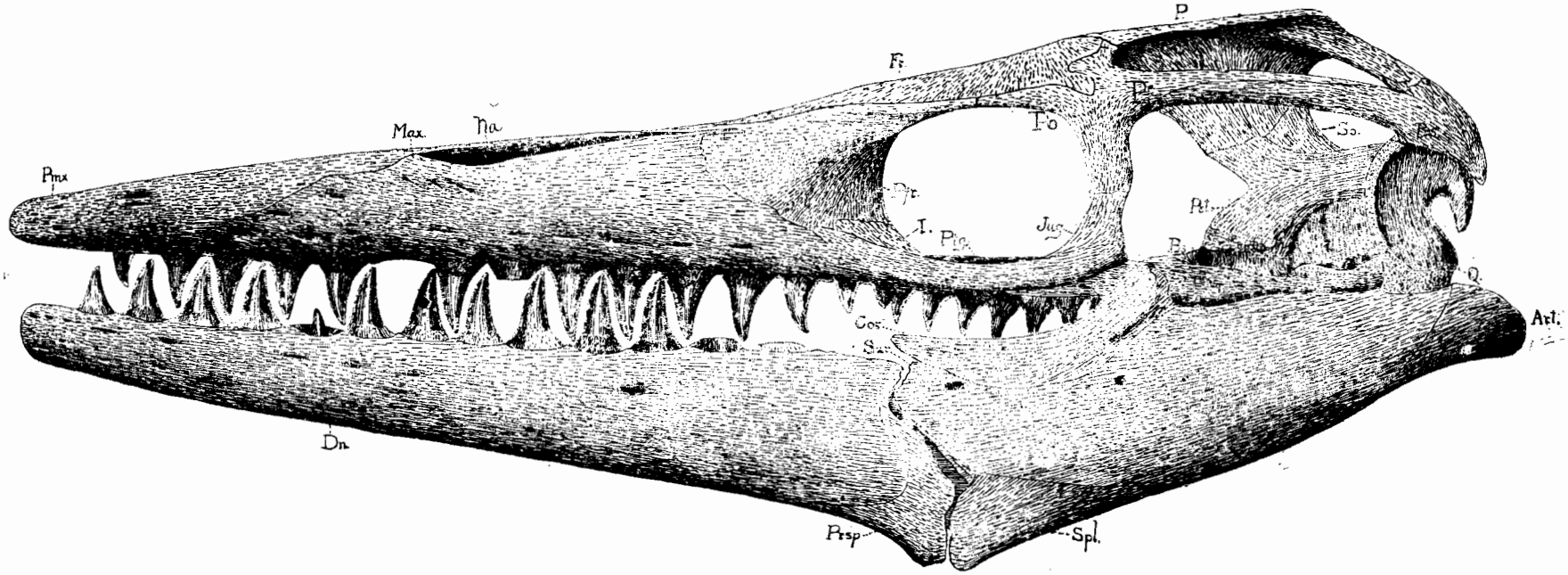
PLATECARPUS CORYPHÆUS COPE, × two-fifths.



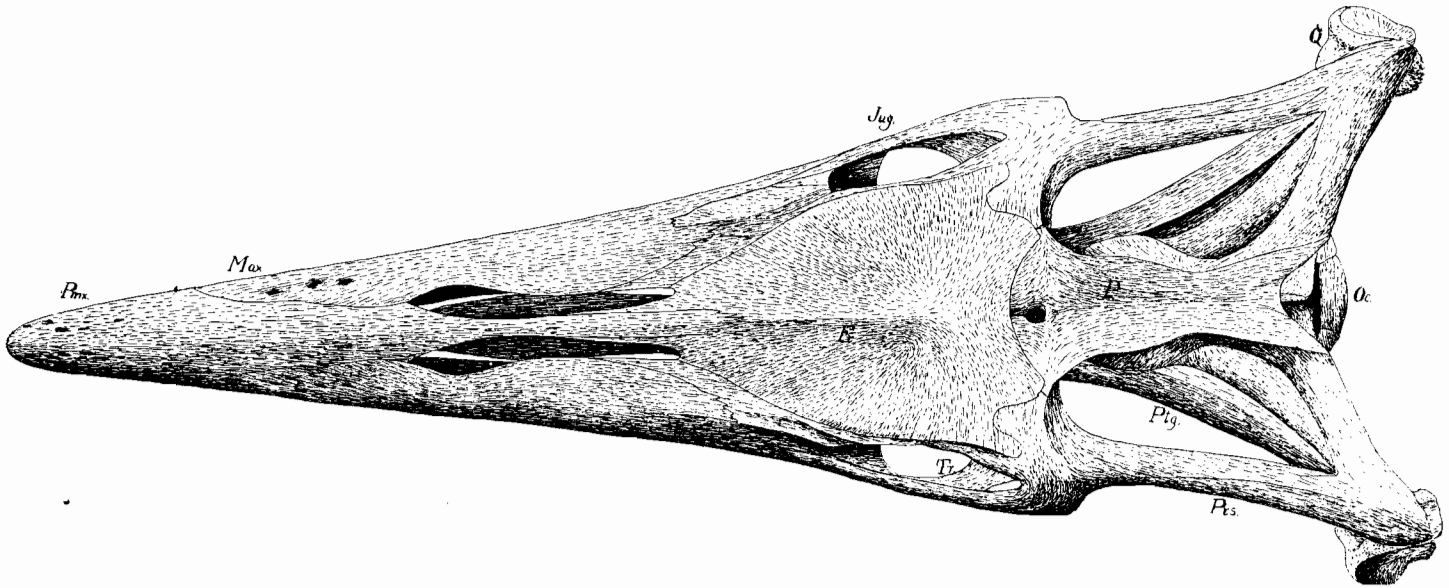
PLATECARPUS CORYPHÆUS (from above), × one-third.



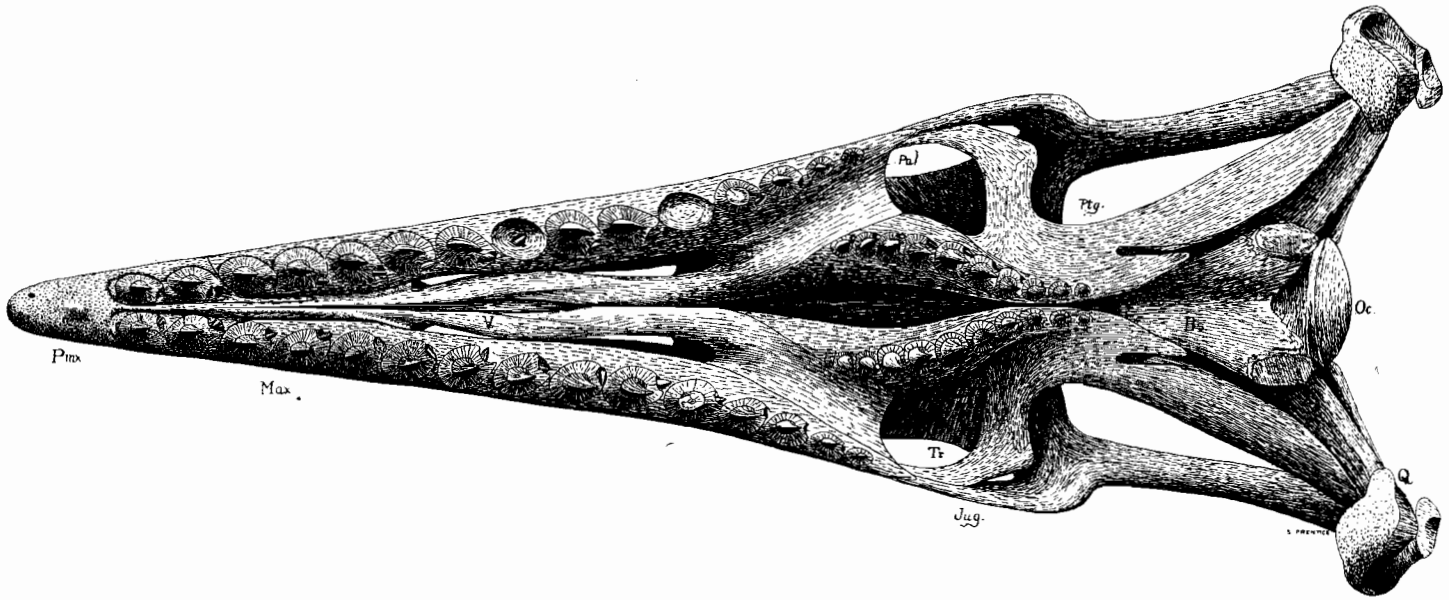
PLATECARPUS CORYPHÆUS (from below), × one-third.



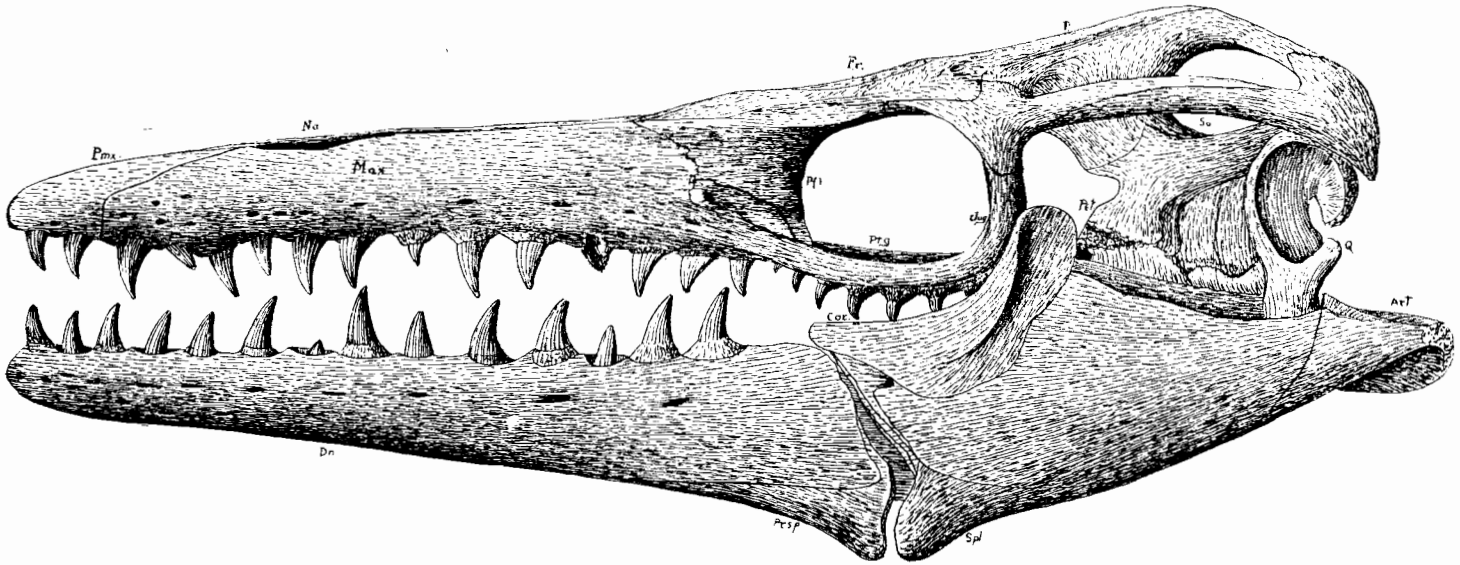
TYLOSAURUS PRORIGER COPE, × two-ninths.



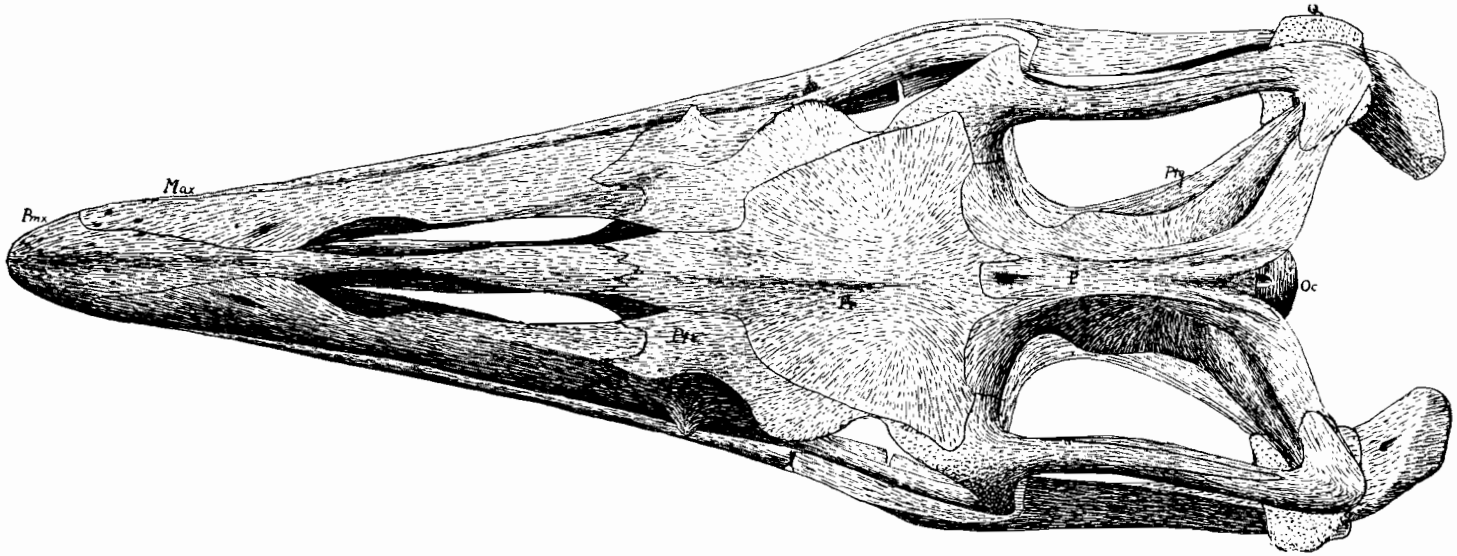
TYLOSAURUS PRORIGER (from above), × one-fifth.



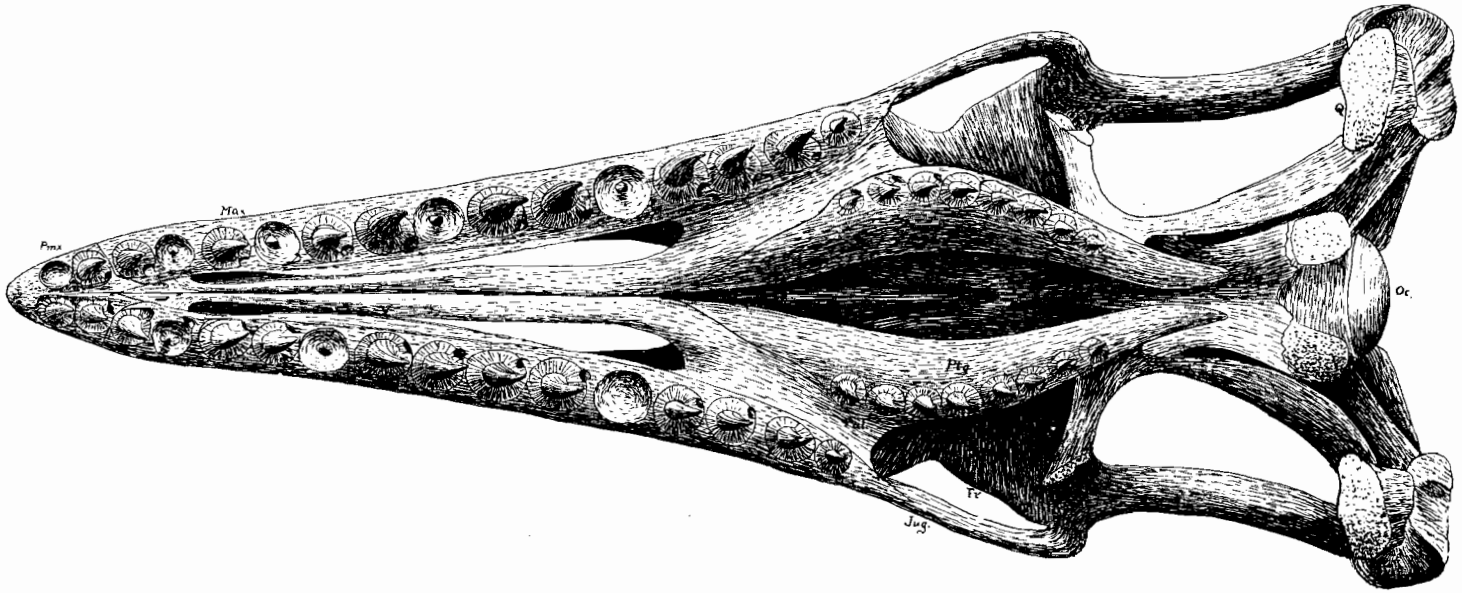
TYLOSAURUS PRORIGER (from below), × one-third.



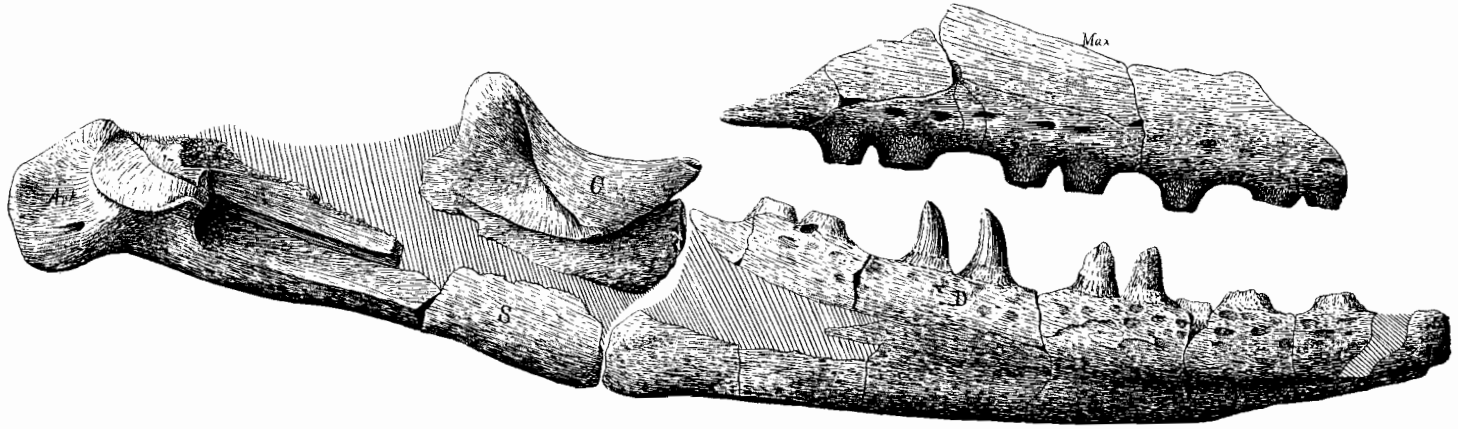
MOSASAURUS HORRIDUS WILLISTON, × three-sixteenths.



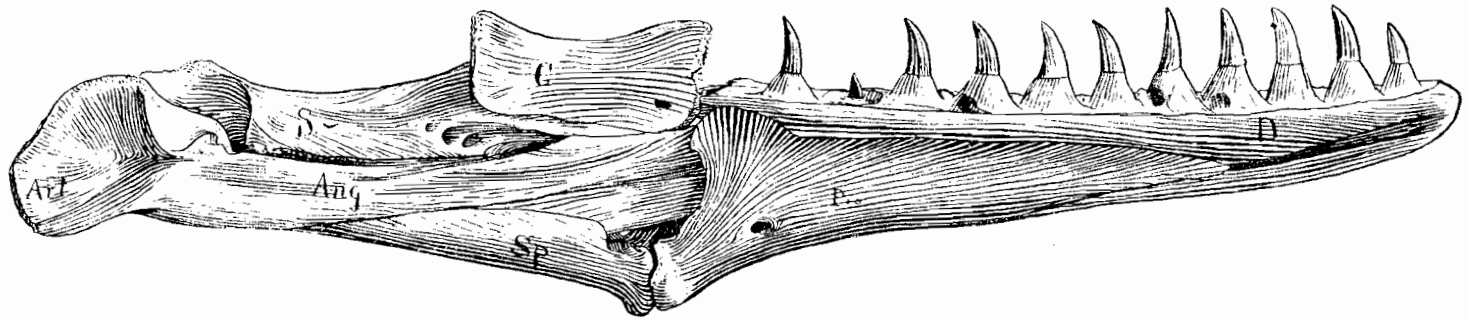
MOSASAURUS HORRIDUS (from above), × three-sixteenths.



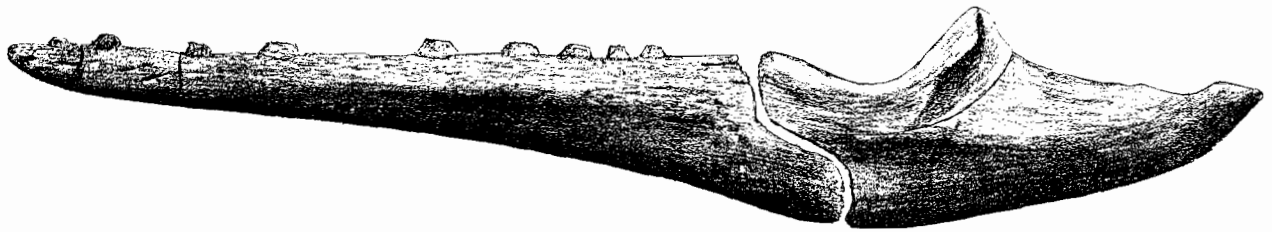
MOSASAURUS HORRIDUS (from below), × three-sixteenths.



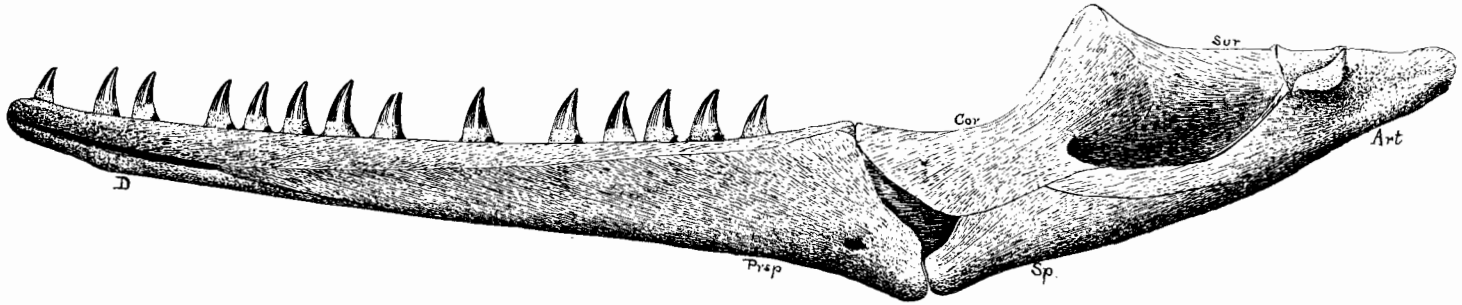
BRACHYSAURUS OVERTONII WILLISTON, × one-sixth.



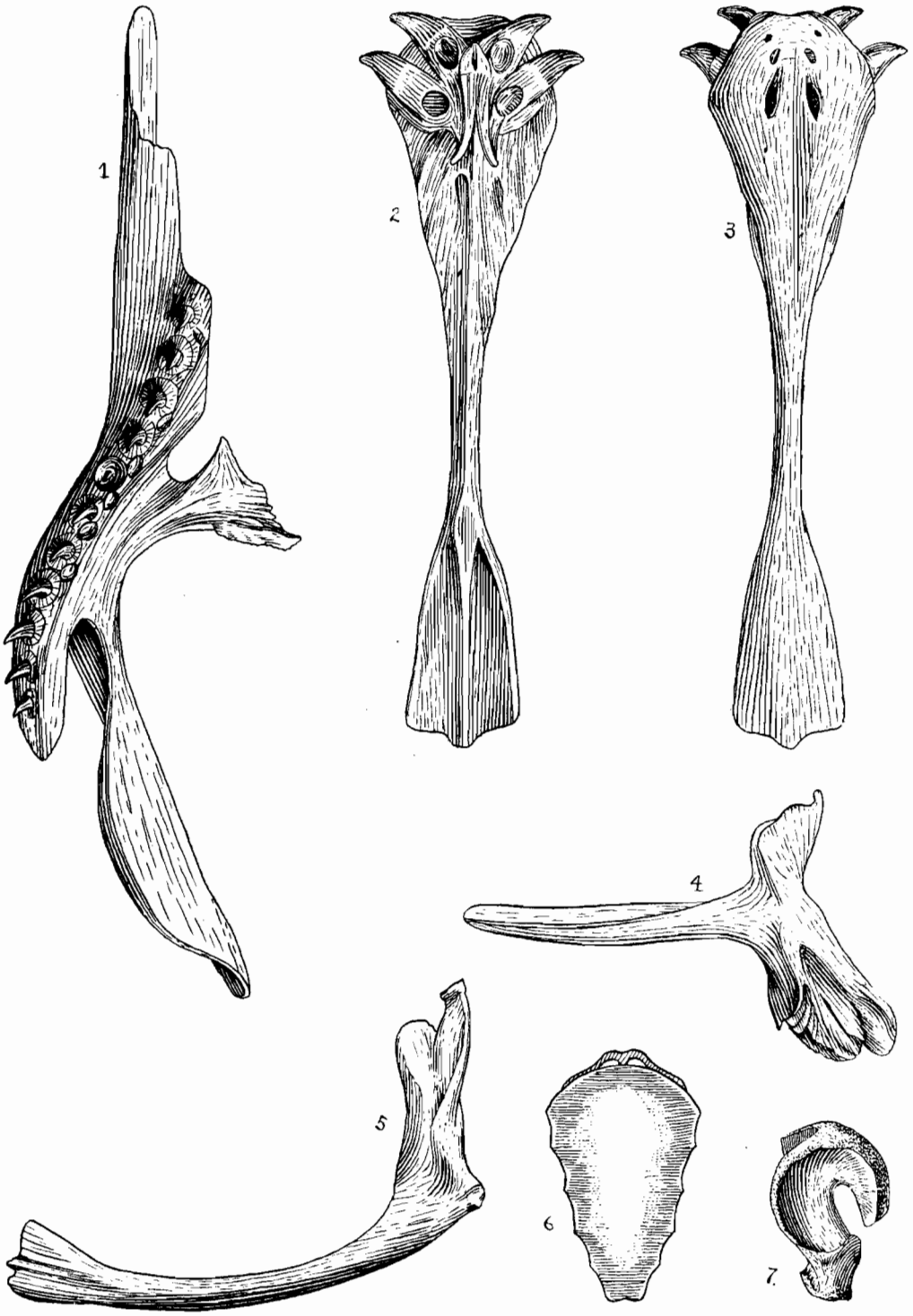
PLATECARPUS CORYPHÆUS COPE, × one-third.



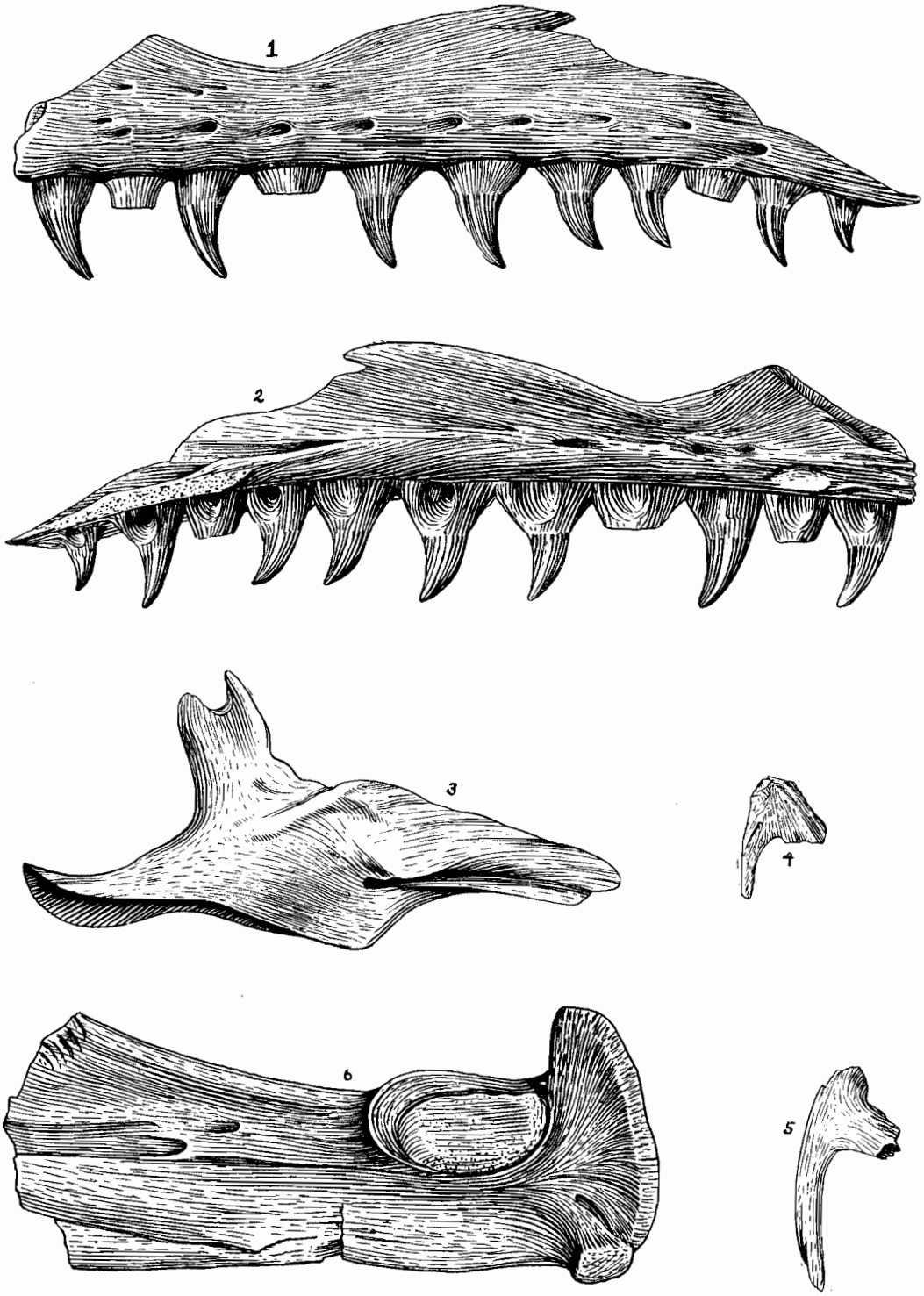
CLIDASTES WESTII WILLISTON, × one-fourth.



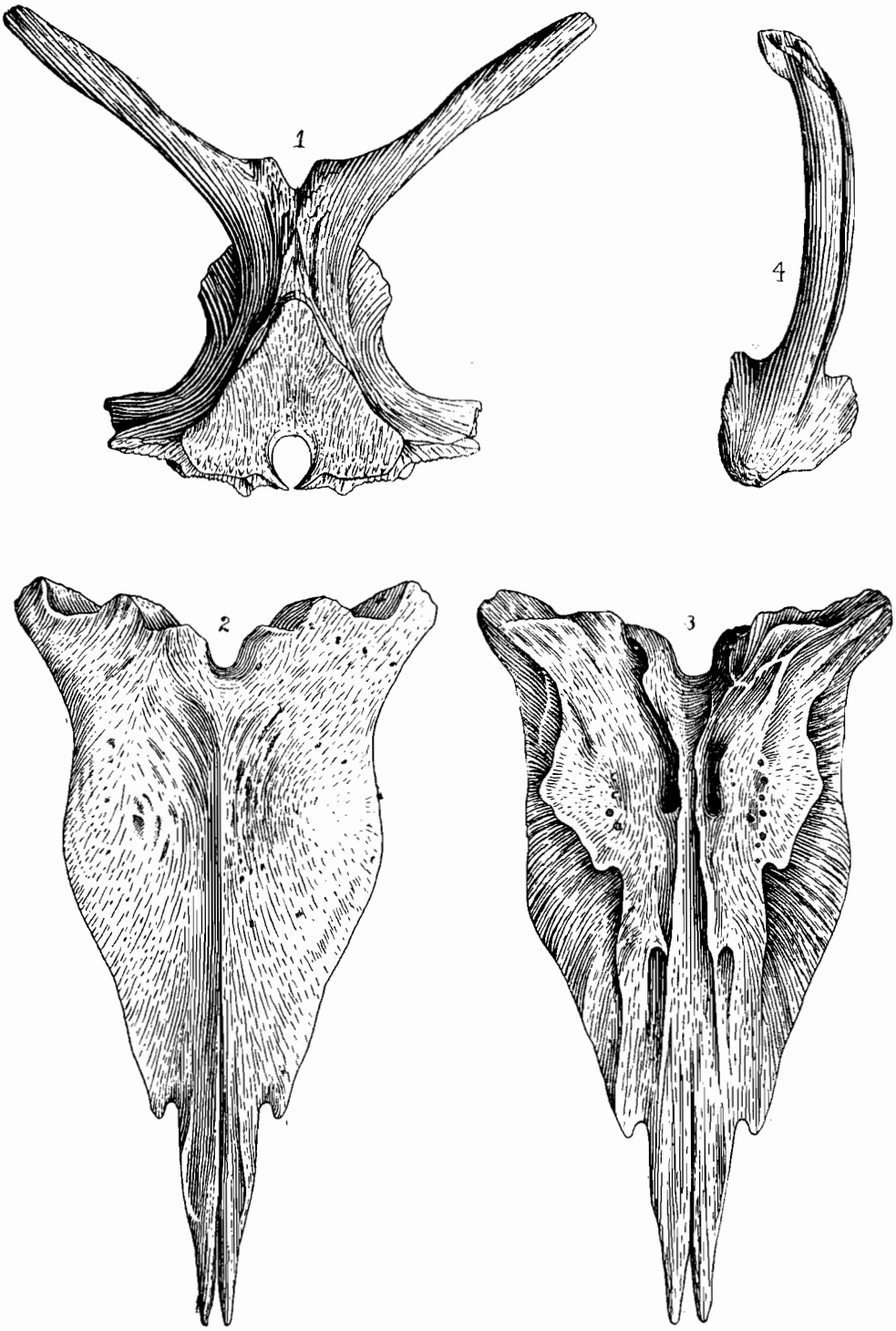
CLIDASTES TORTOR COPE, × one-fourth.



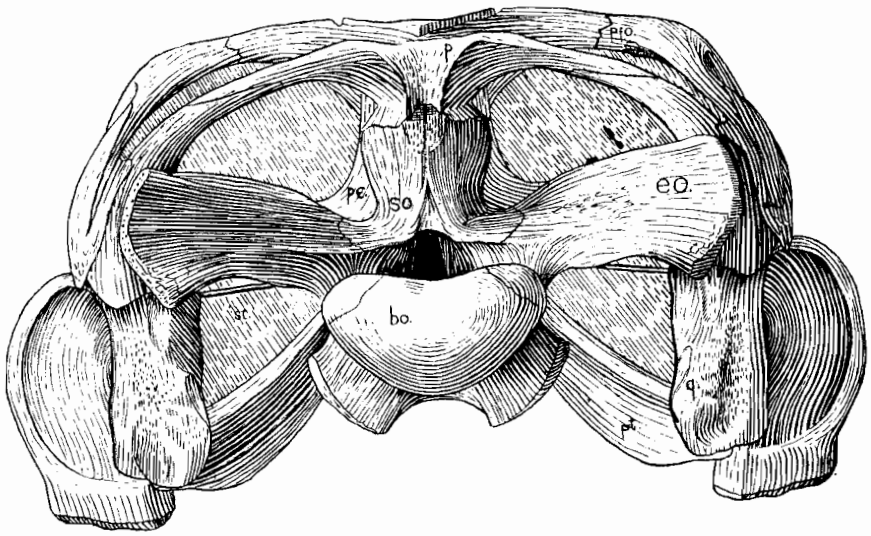
PLATECARPUS CORYPHÆUS—1, 2, 3, 4, 5.
CLIDASTES VELOX—6, 7.
} × one-half.



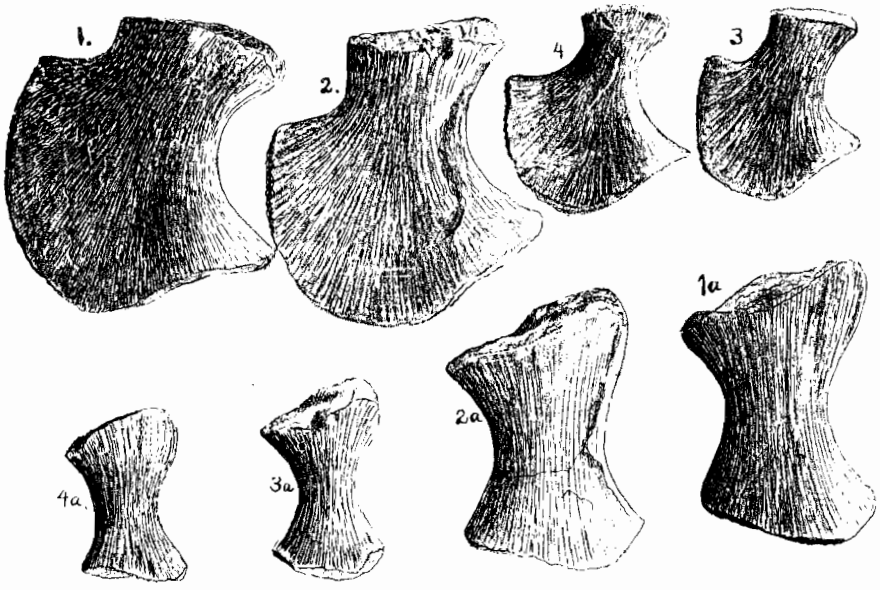
PLATECARPUS CORYPHÆUS—1, 2, 3, 4, 5.
BAPTOSAURUS ONCHOGNATHUS—6. } × one-half.



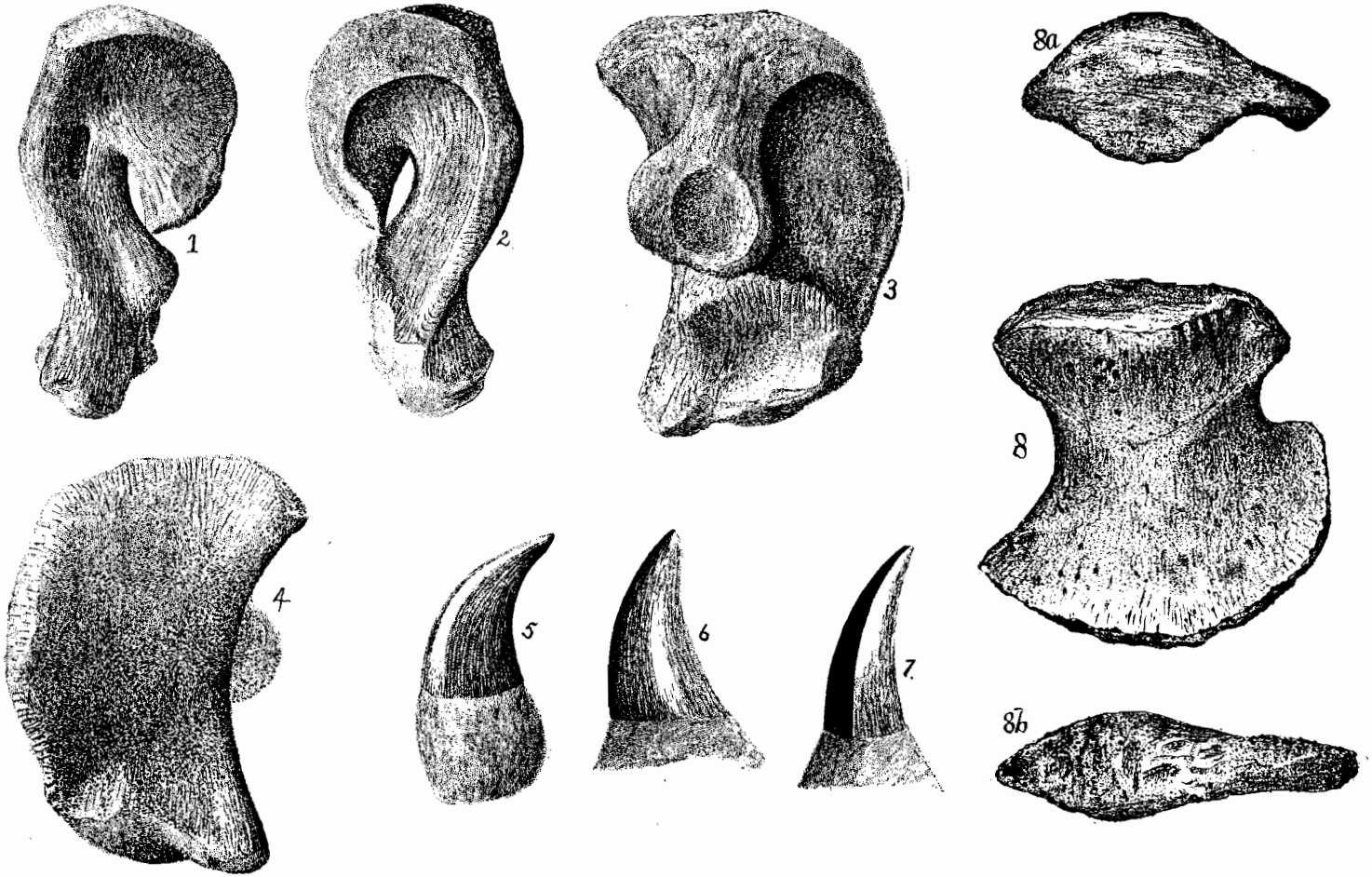
PLATECARPUS CORYPHÆUS, × one-half.



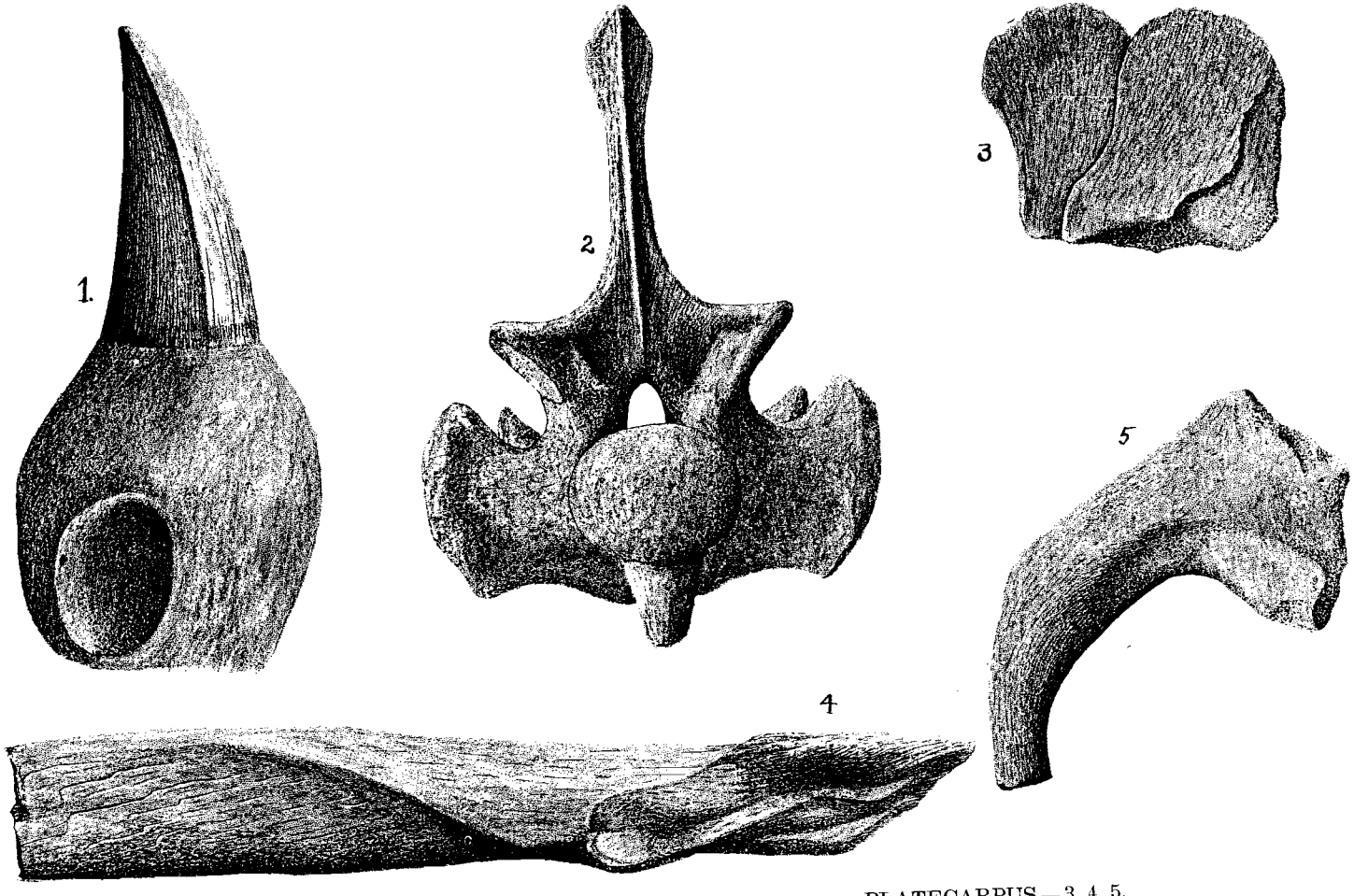
PLATECARPUS CORYPHÆUS, × one-half.



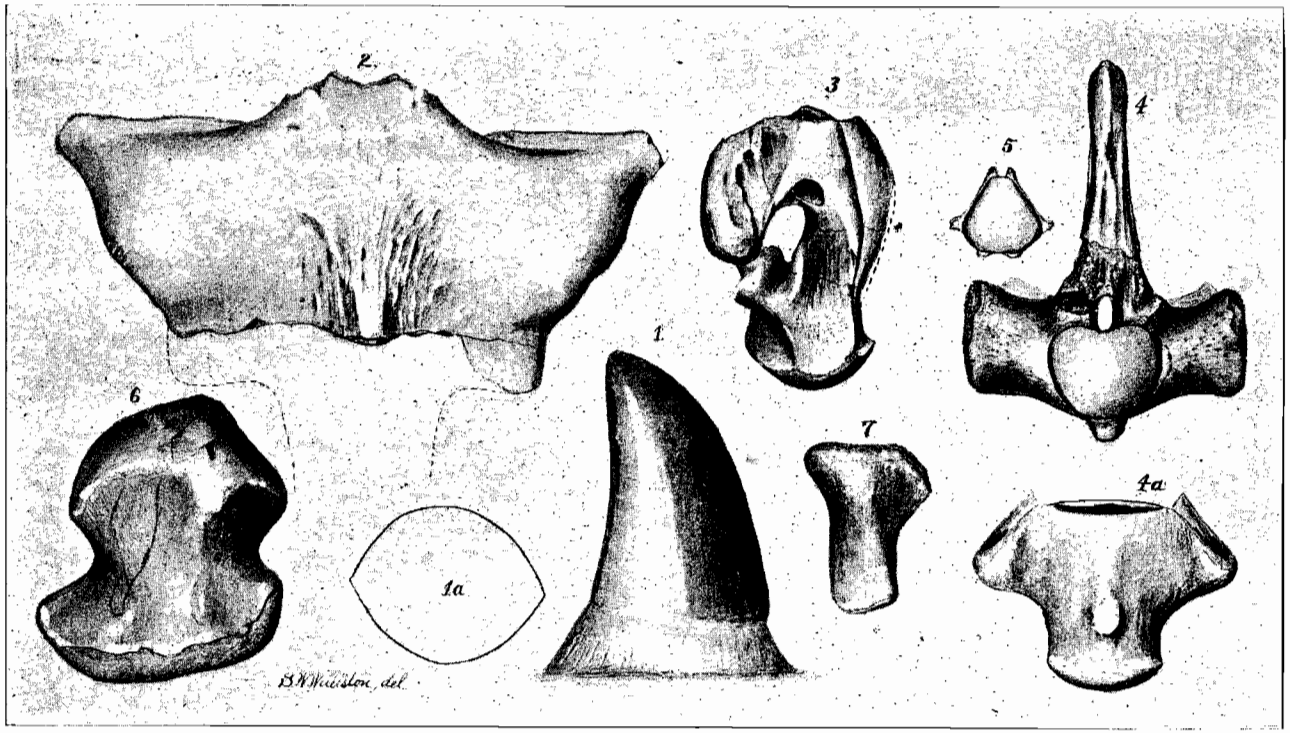
CLIDASTES { WESTII—1, 1a, TORTOR—2, 2a, VELOX—3, 4, 3a, 4a, } × one-half.



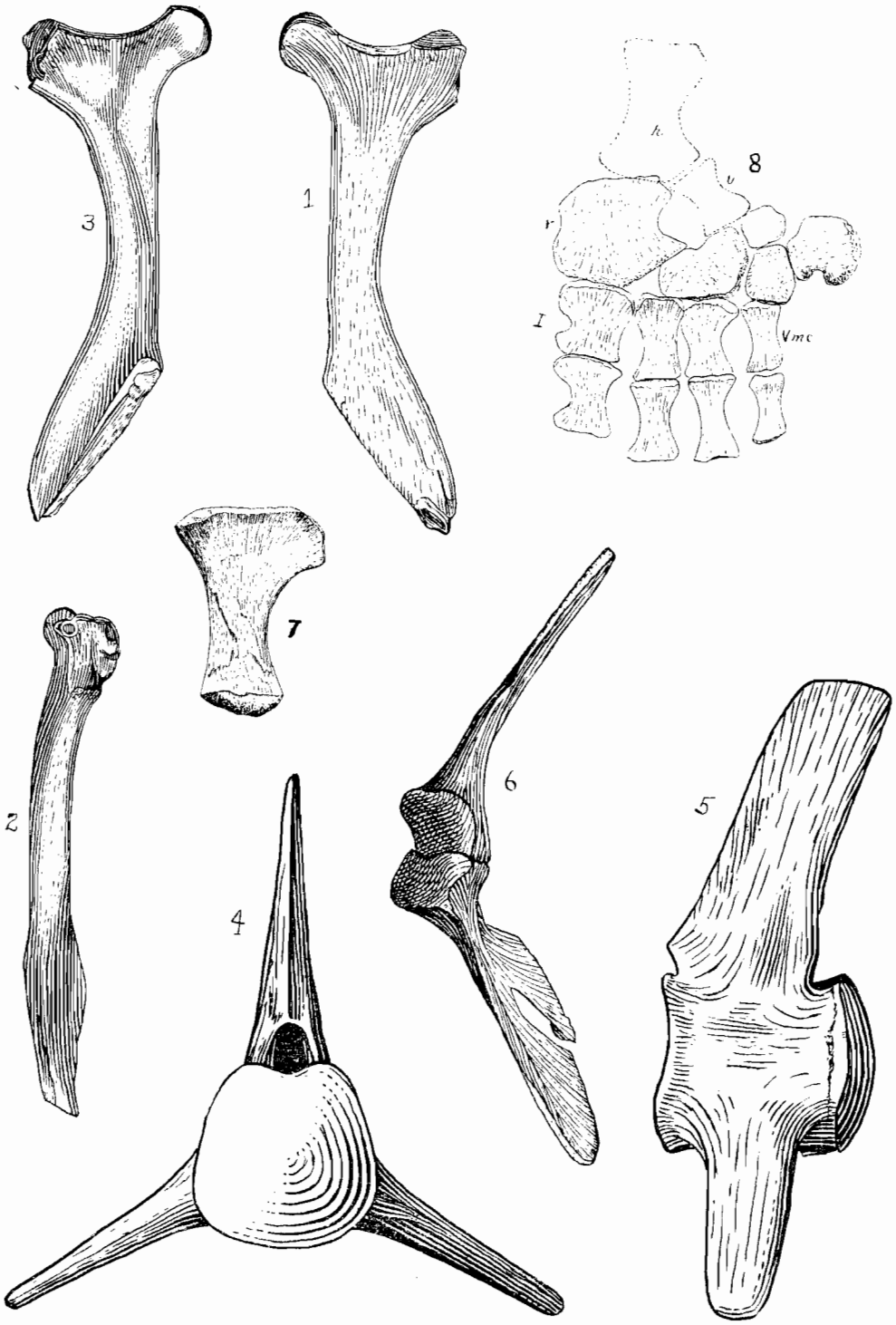
PLATECARPUS—5, 6, 7, 8. CLIDASTES—1, 2, 3, 4.



TYLOSAURUS—1. CLIDASTES—2. PLATECARPUS—3, 4, 5.

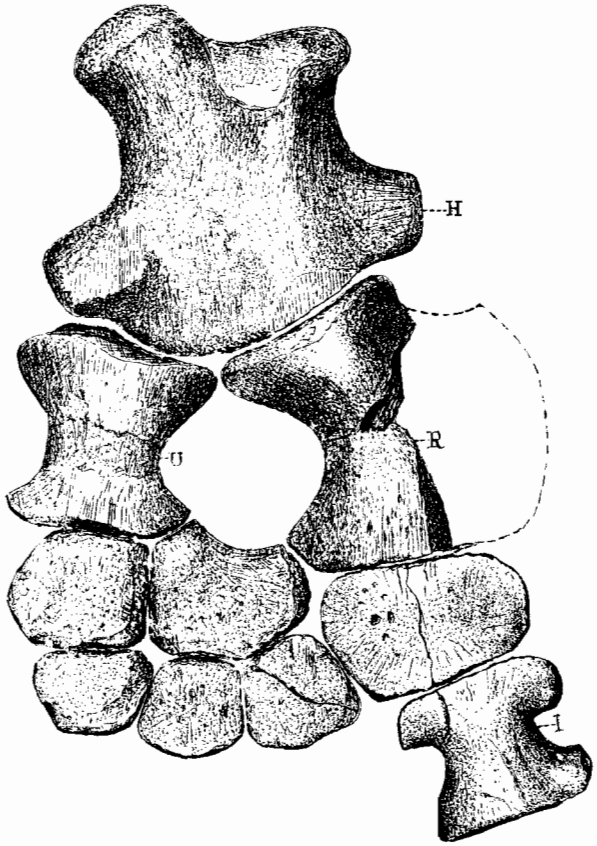


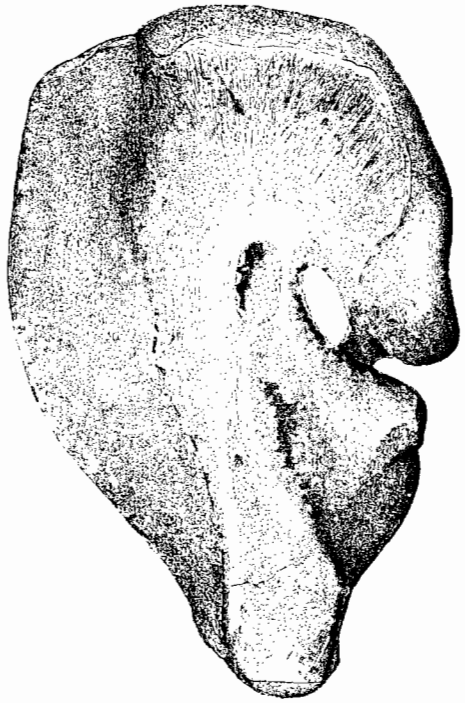
BRACHYSAURUS OVERTONII.



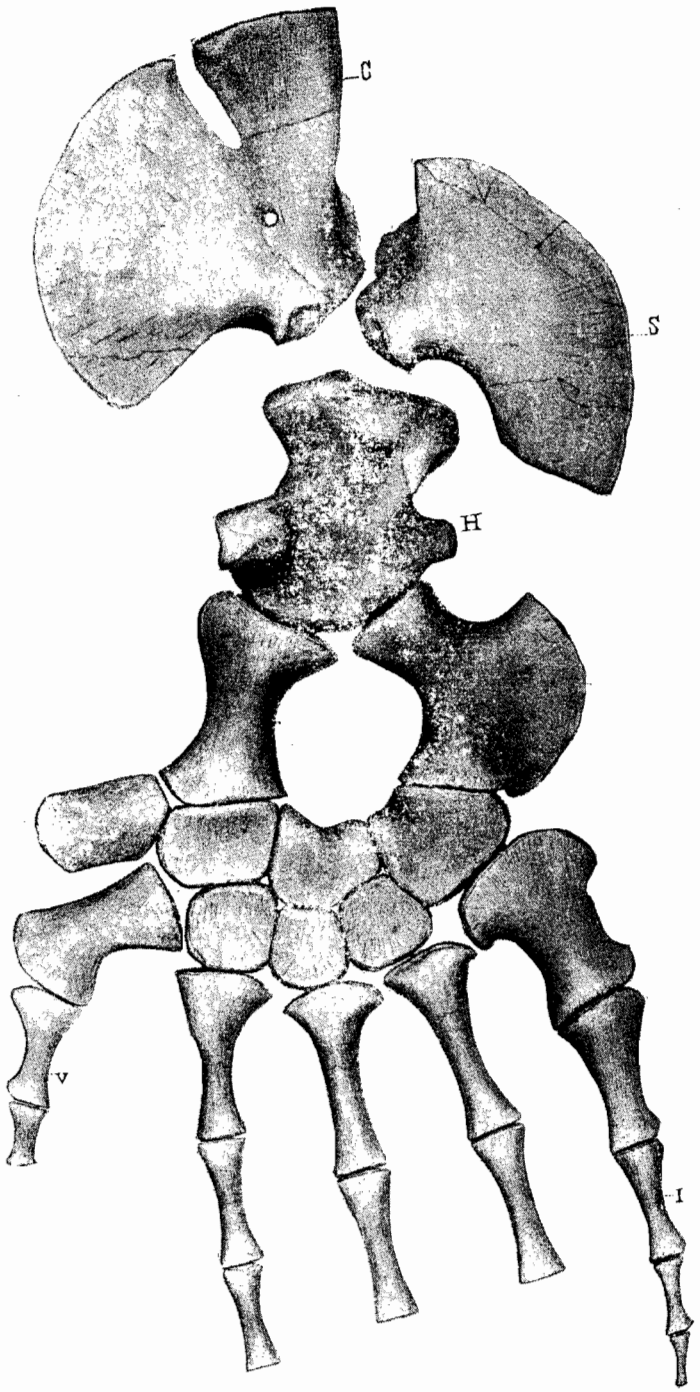
PLATECARPUS — 1, 2, 3, 4, 5, 7. CLIDASTES — 6.

MOSASAURUS — 8.

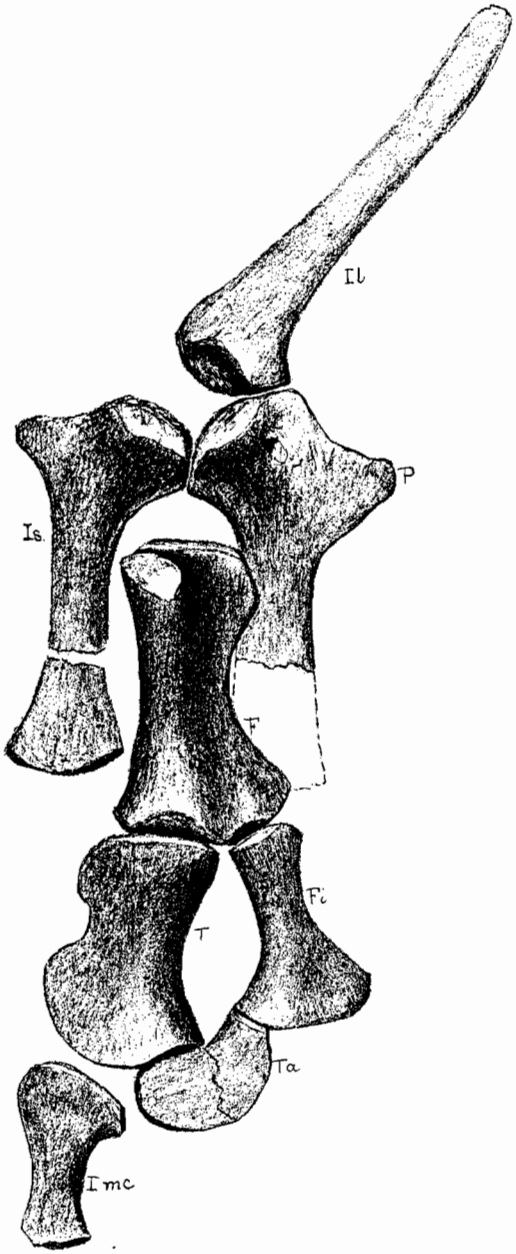




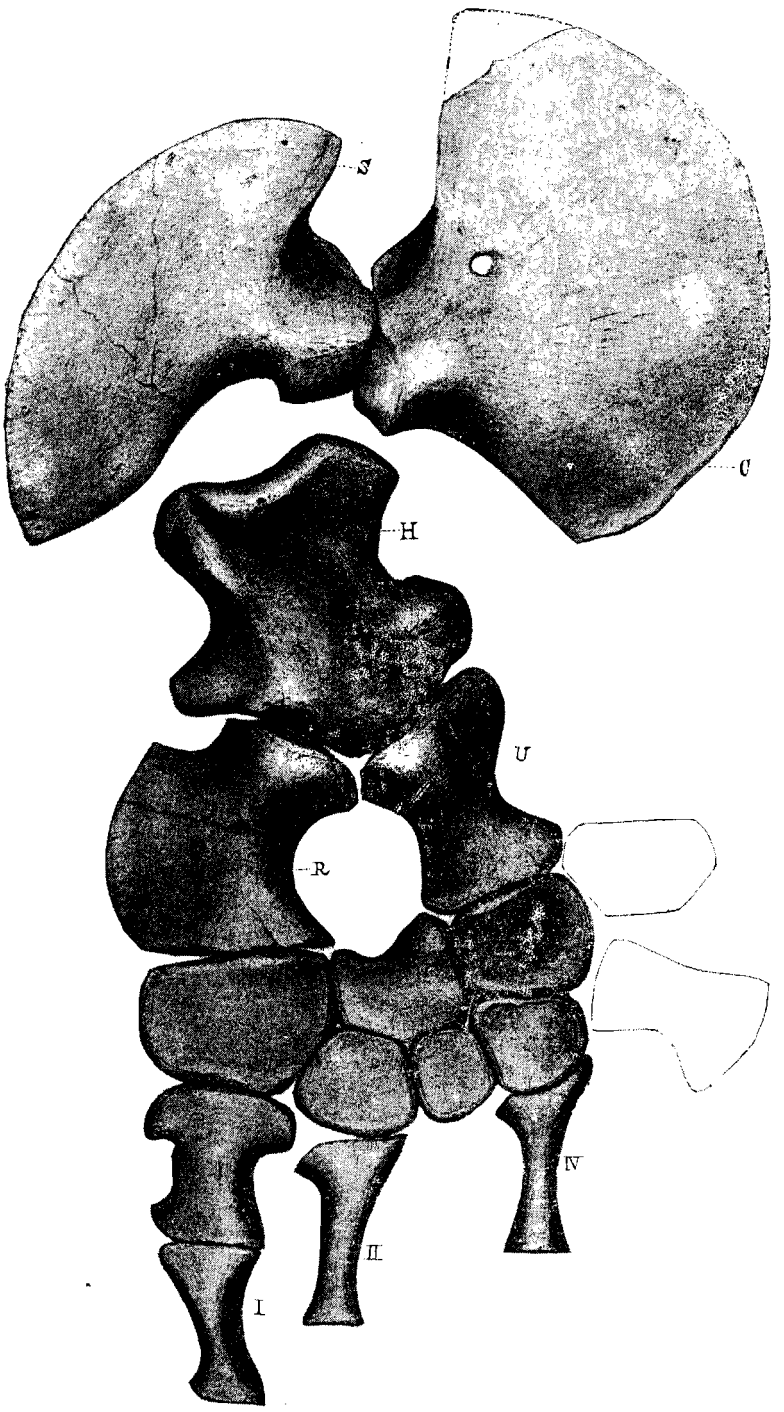
MOSASAURUS HORRIDUS.



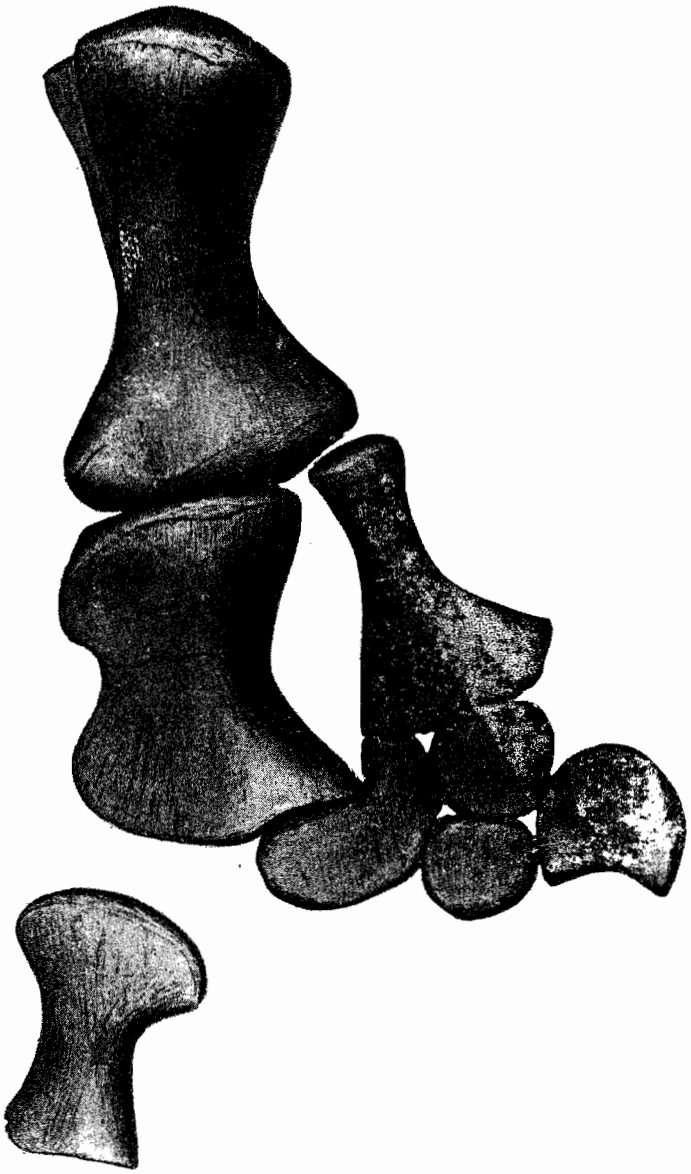
CLIDASTES VELOX, × two-thirds.



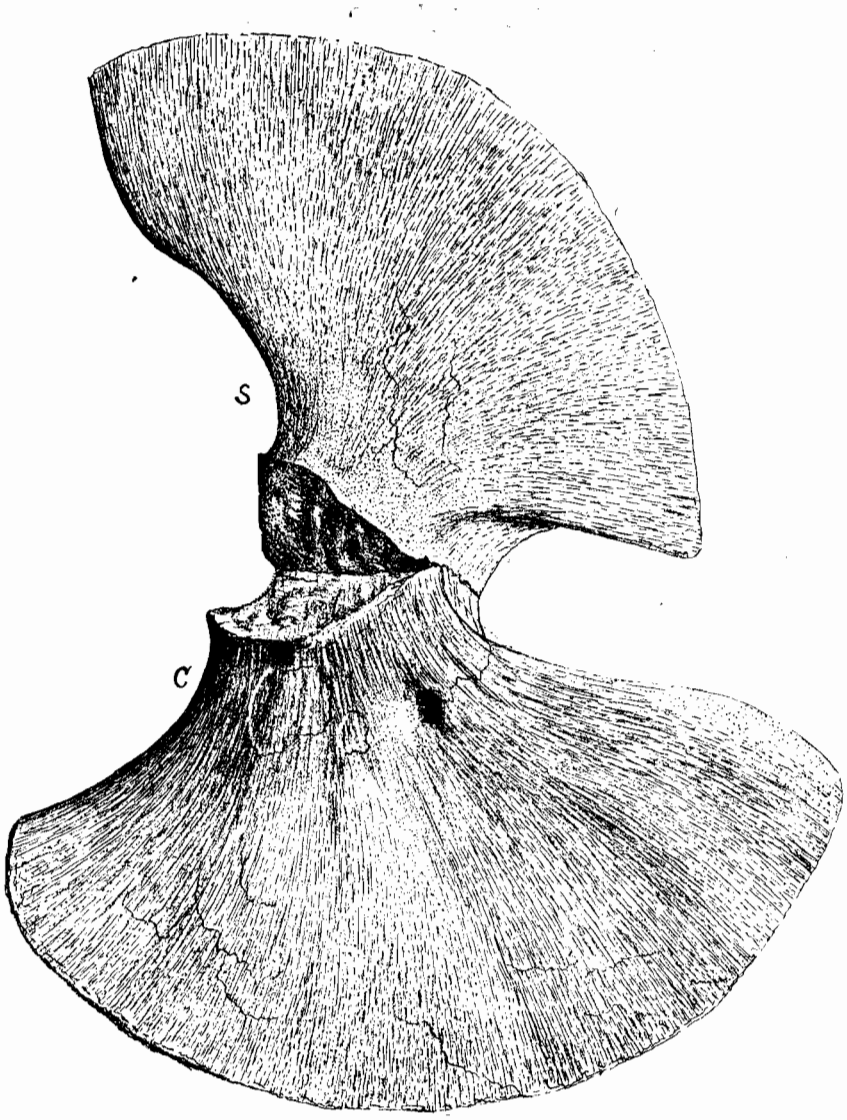
CLIDASTES VELOX, × two-thirds.



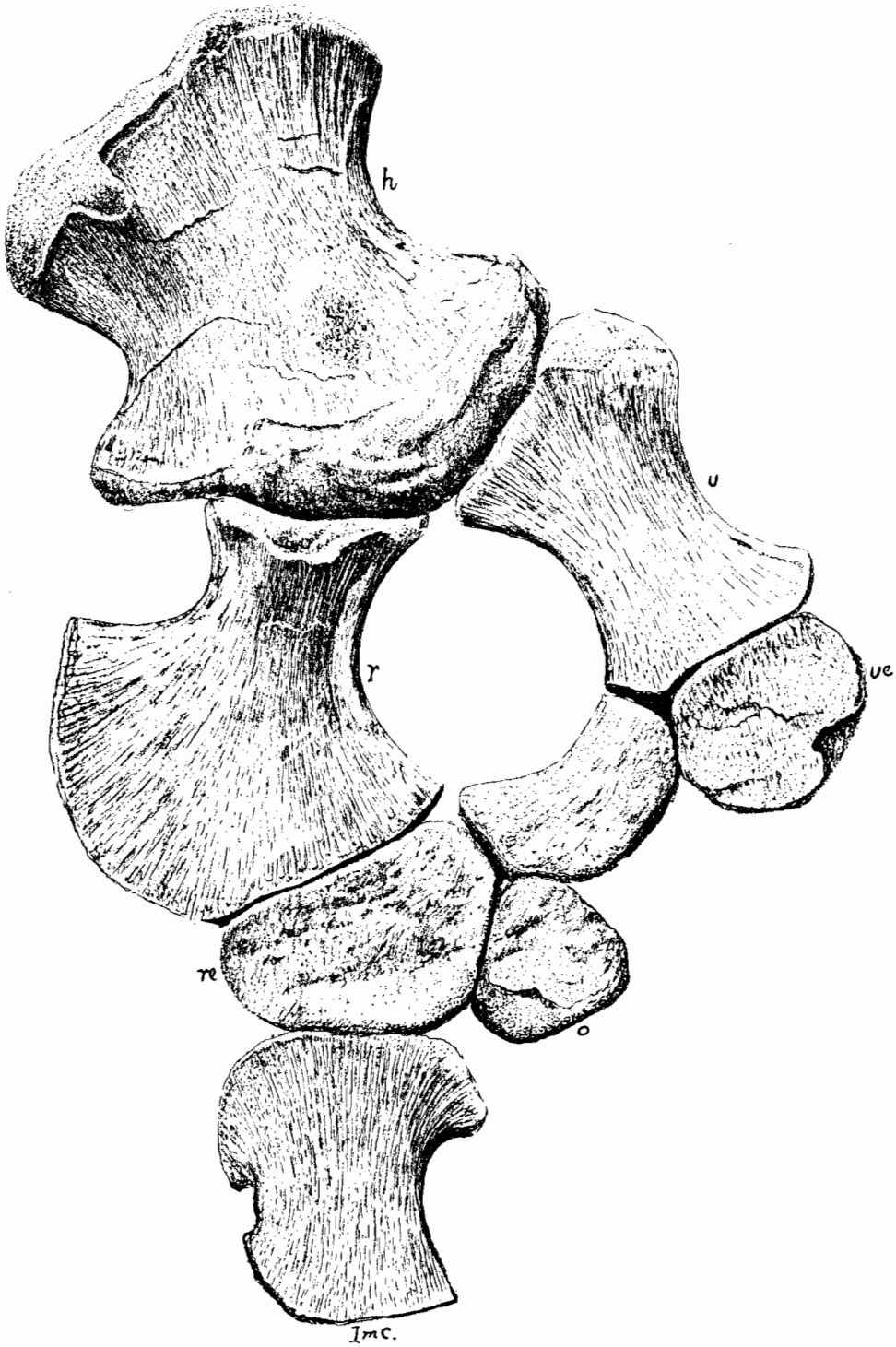
CLIDASTES WESTII, × one-third.



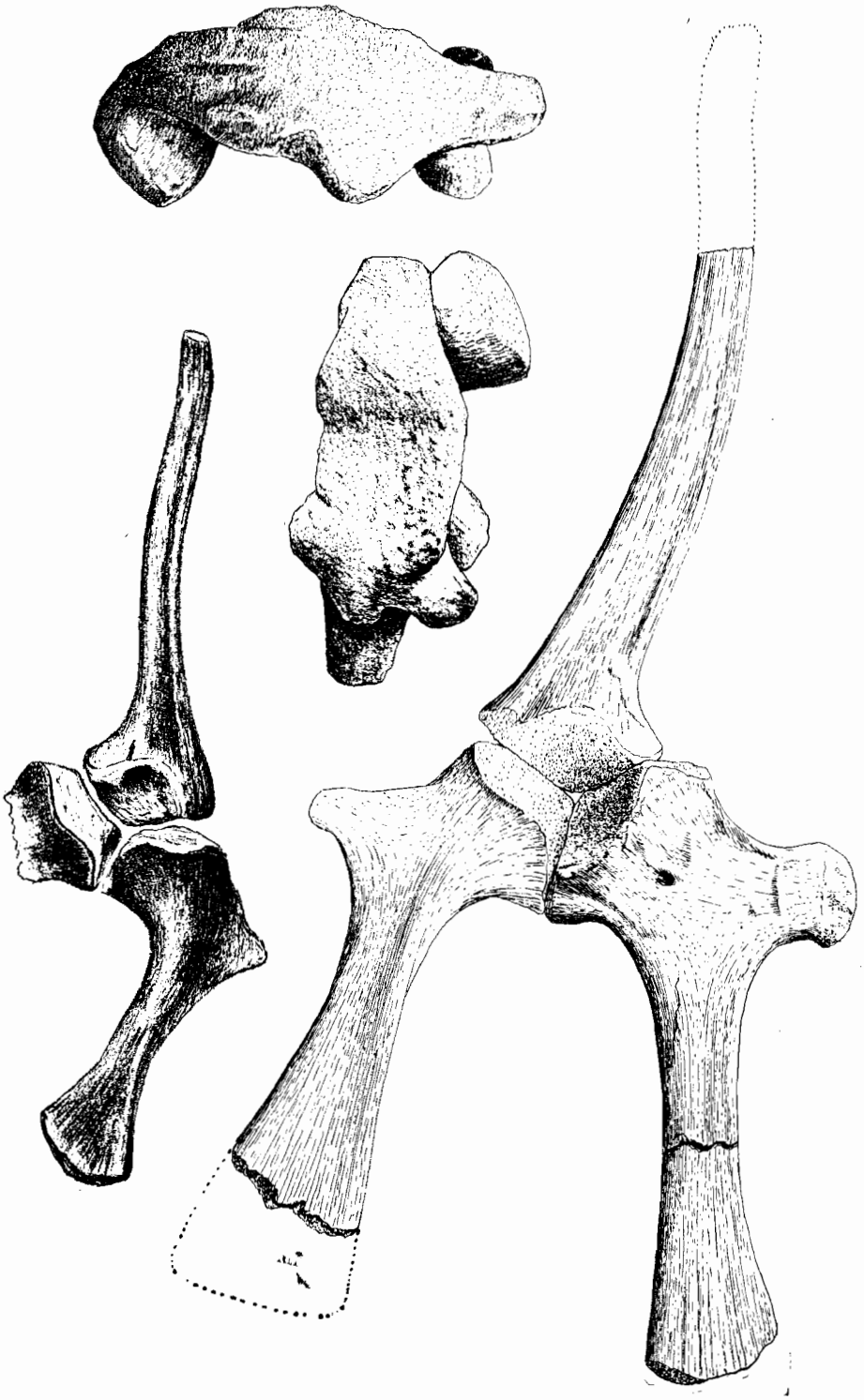
CLIDASTES WESTII, × two-thirds.



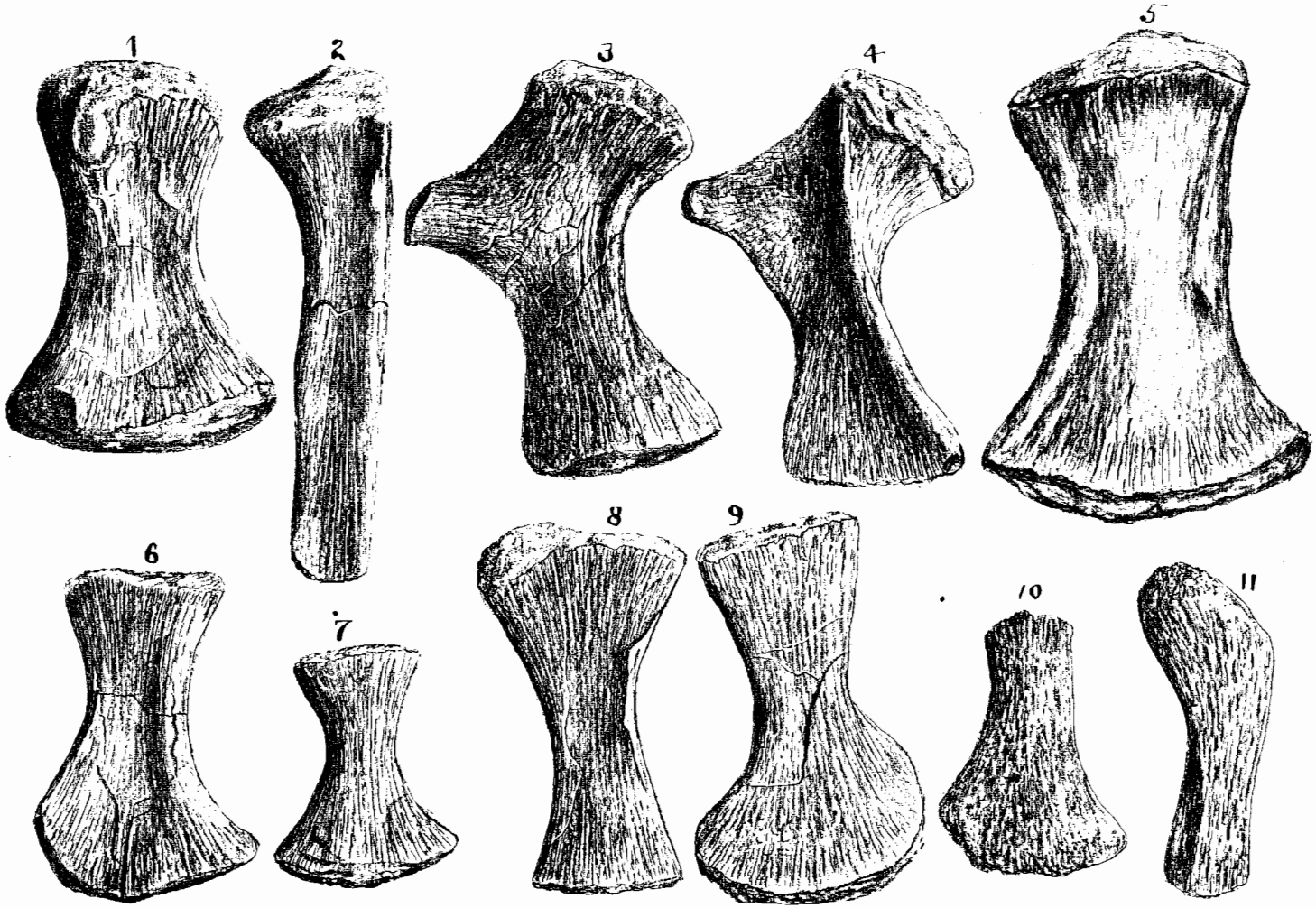
CLIDASTES TORTOR, × two-thirds.



CLIDASTES TORTOR, × four-fifths.

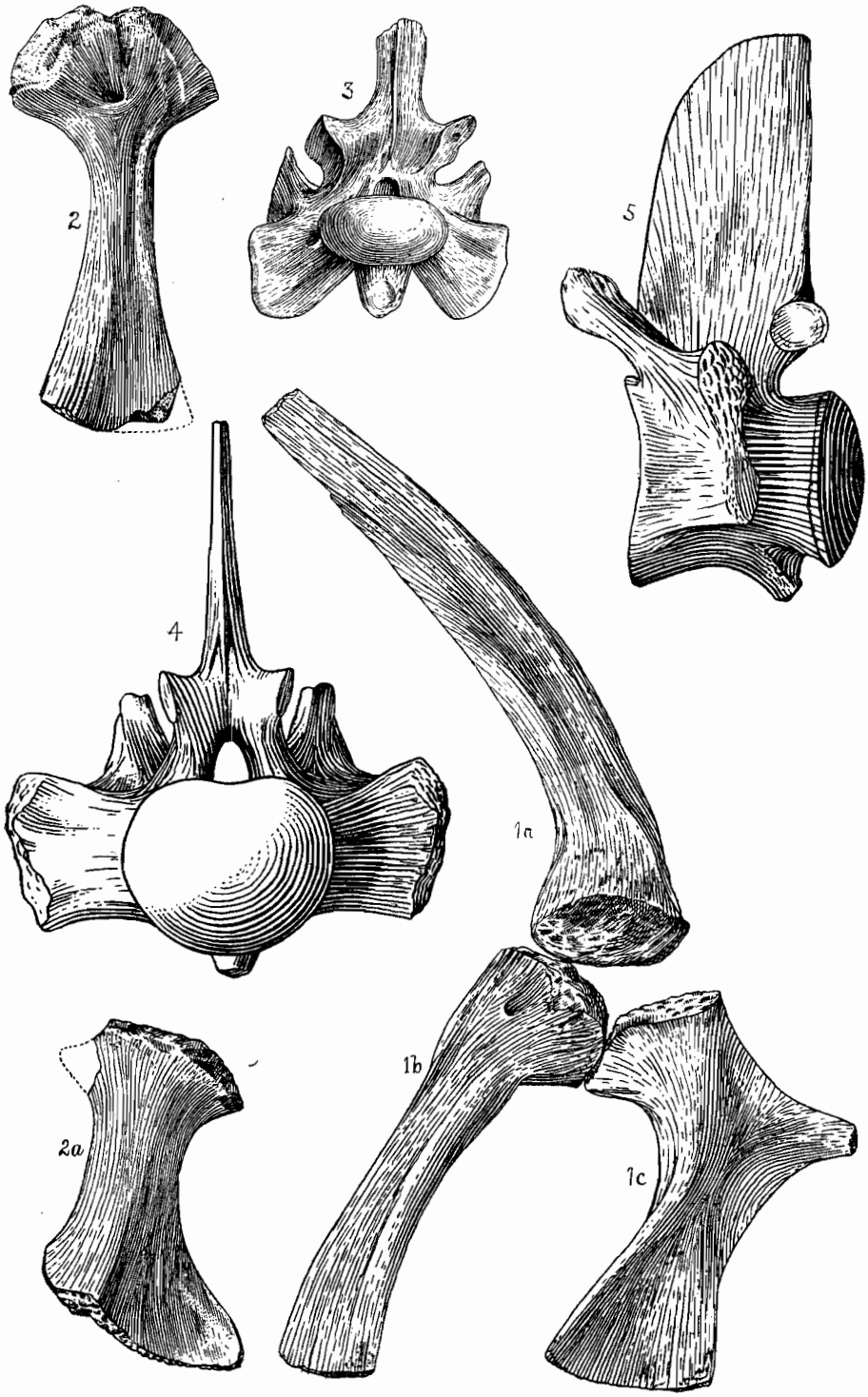


CLIDASTES, × three-fourths.

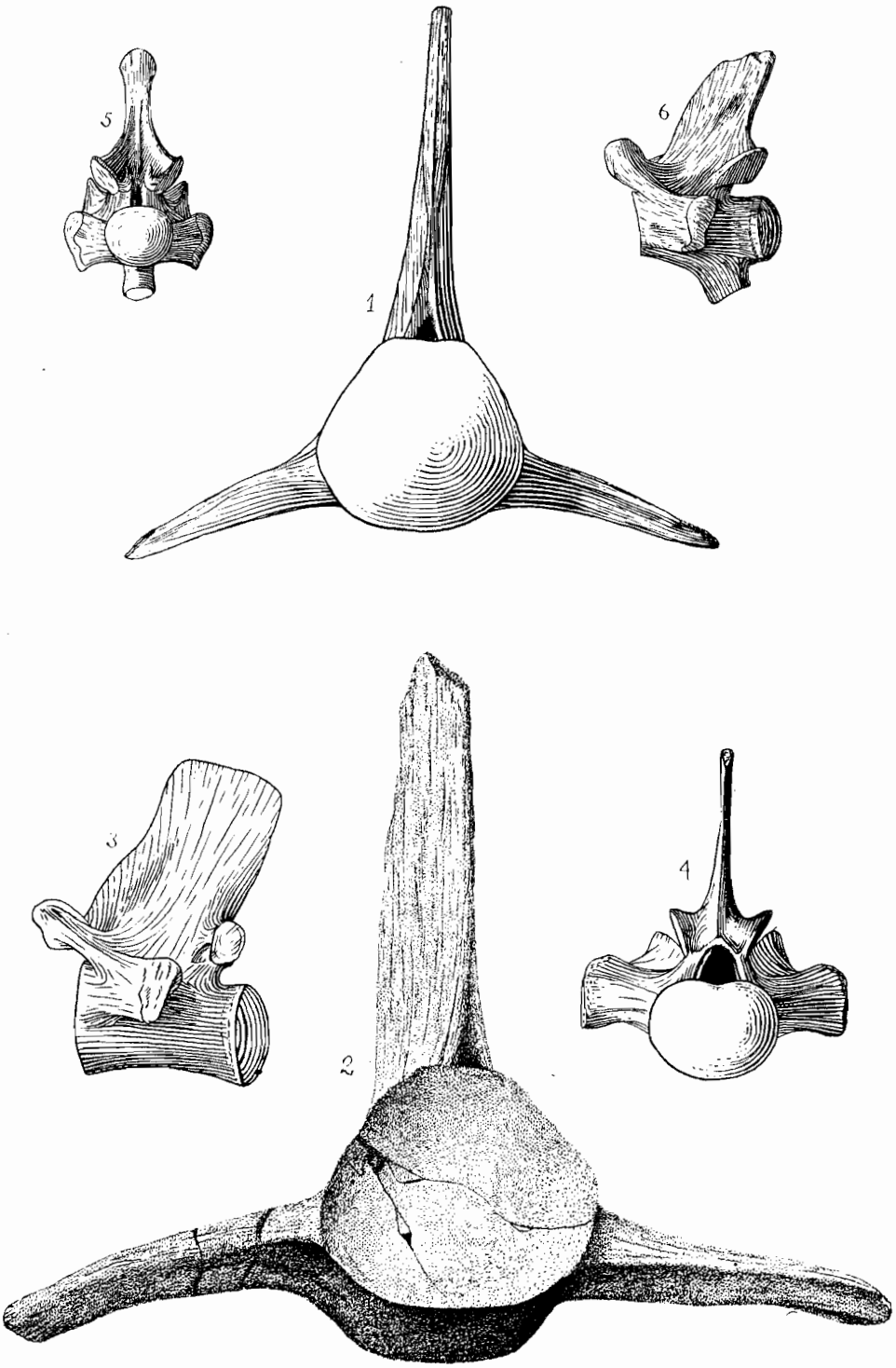


TYLOSAURUS PRORIGER—1 to 9, × one-half.

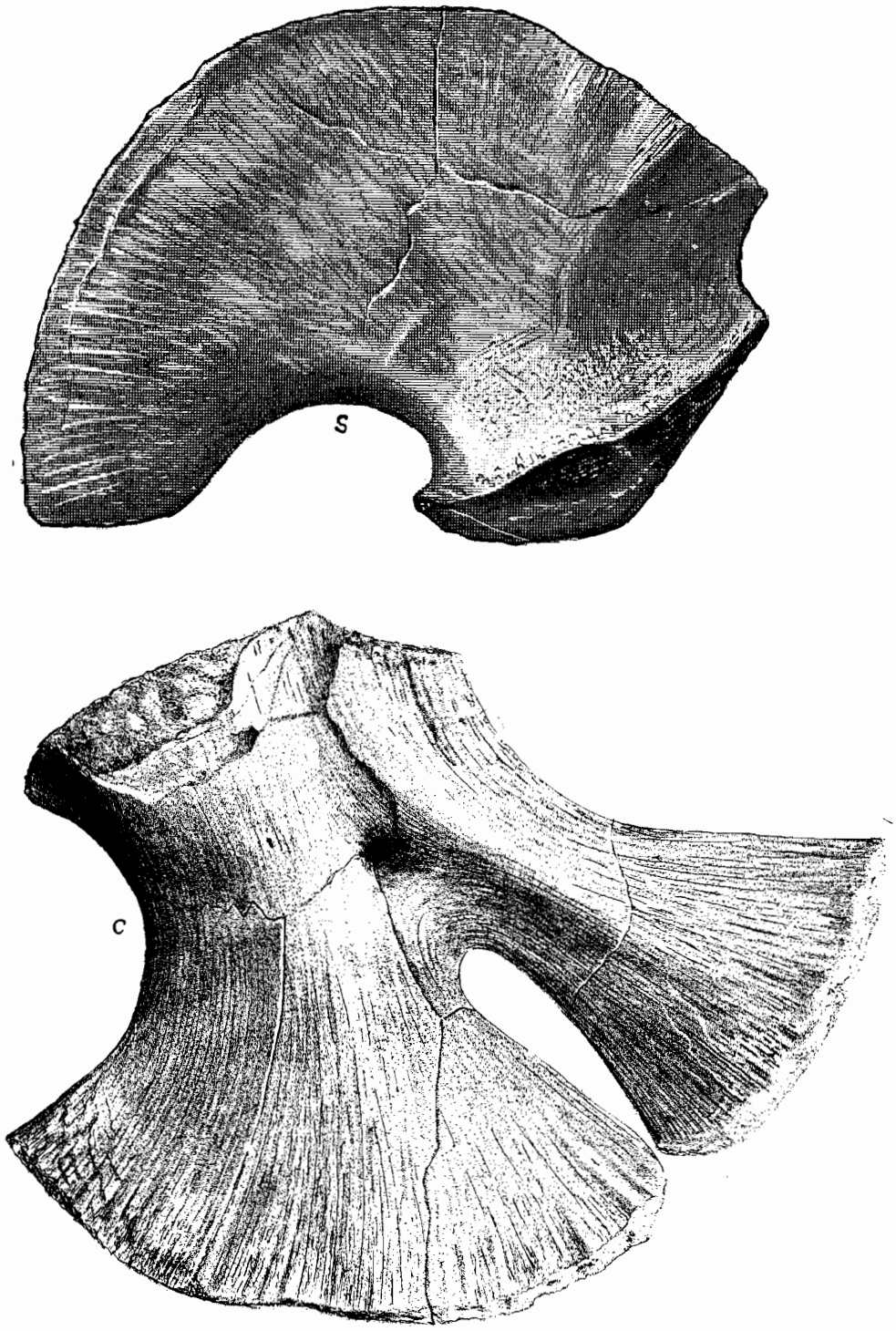
BRACHYSAURUS OVERTONII—10, 11, × one-half.



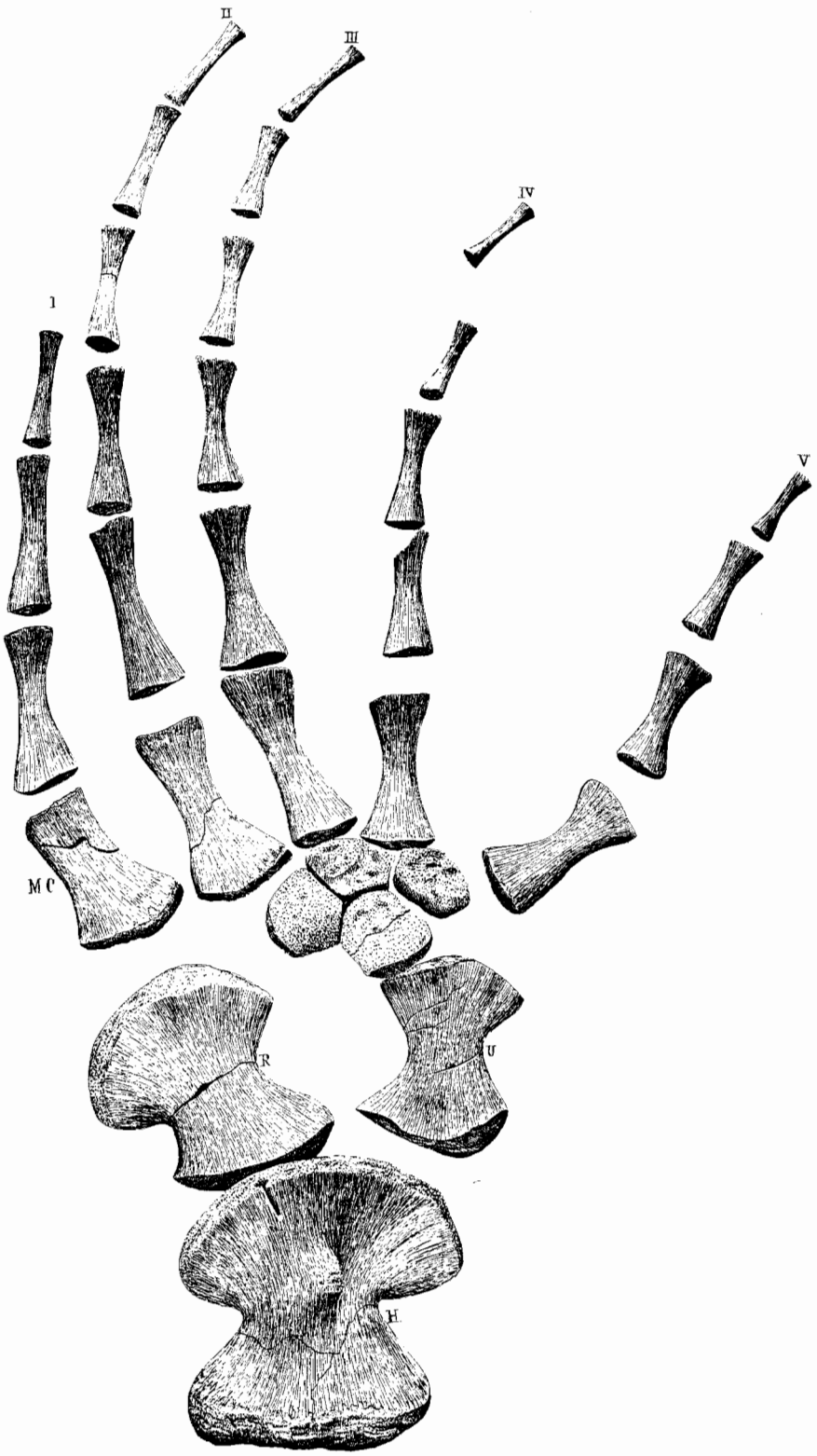
TYLOSAURUS — 1a, 1b, 1c, 4, 5,
PLATECARPUS — 2, 2a,
BAPTOSAURUS ONCHOGNATHUS — 3,
} × three-eighths.



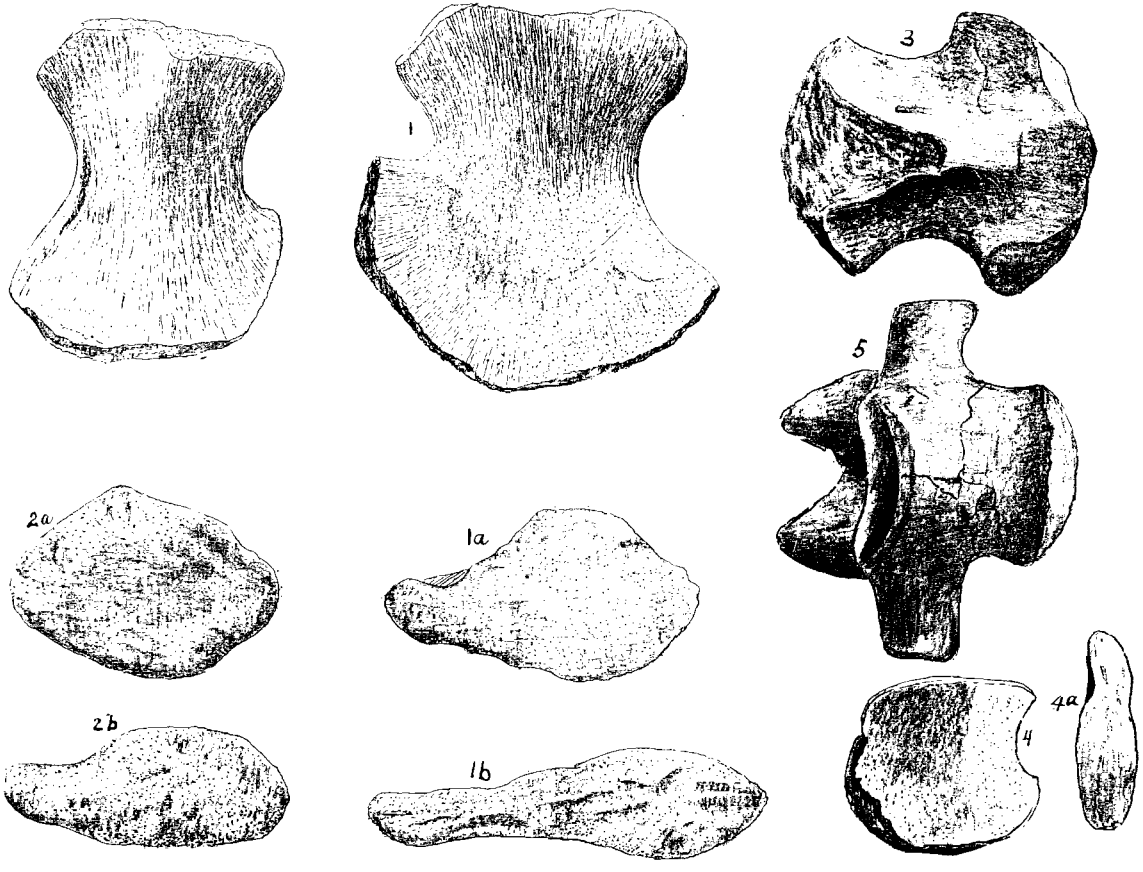
TYLOSAURUS DYSPELOR—1, 2,
PLATECARPUS CORYPHÆUS—3, 4,
CLIDASTES TORTOR—5, 6,
} × three-eighths.



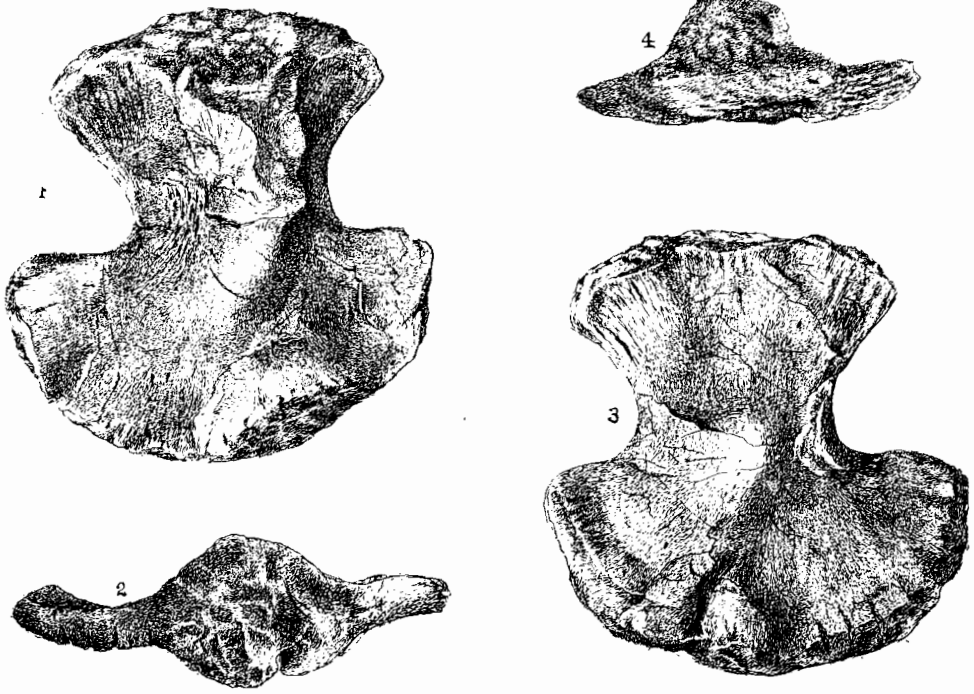
PLATECARPUS ICTERICUS, × five-sevenths.



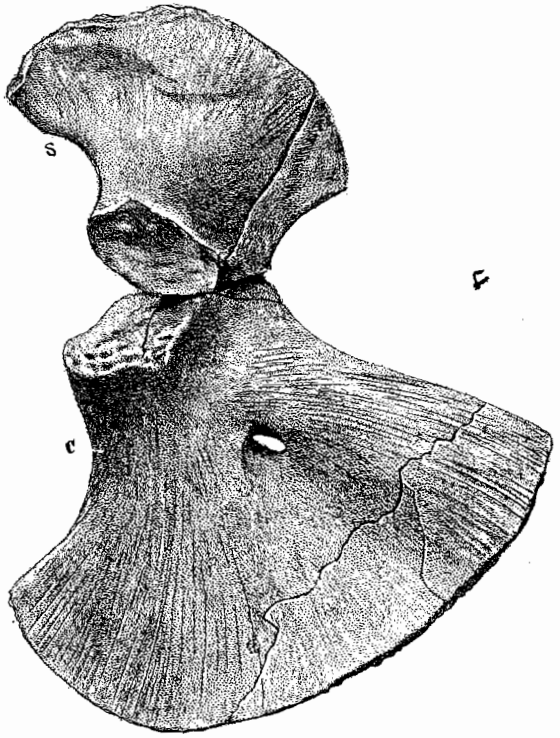
PLATECARPUS ICTERICUS, × one-third.



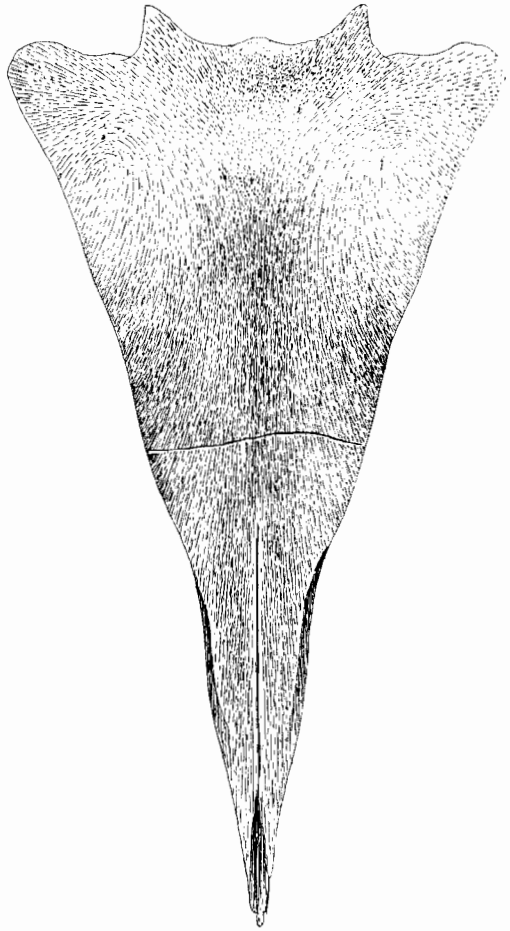
PLATECARPUS.



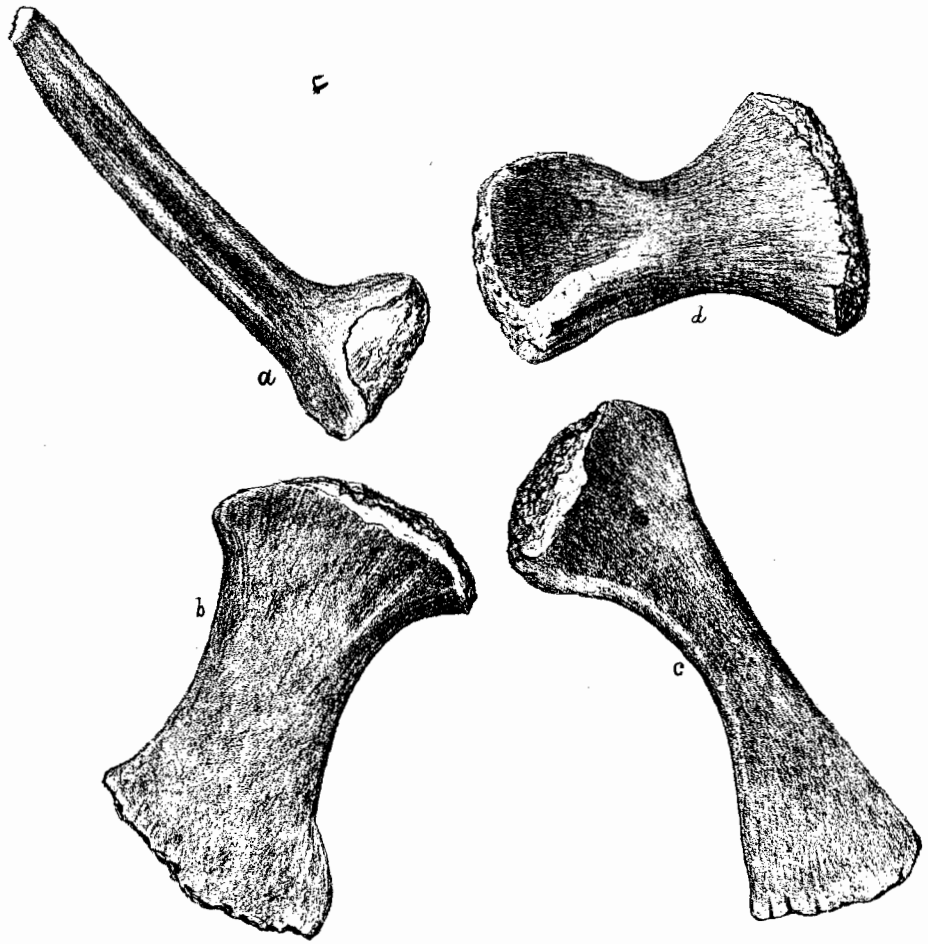
PLATECARPUS CORYPHÆUS—1, 2, 3, 4, × two-thirds.



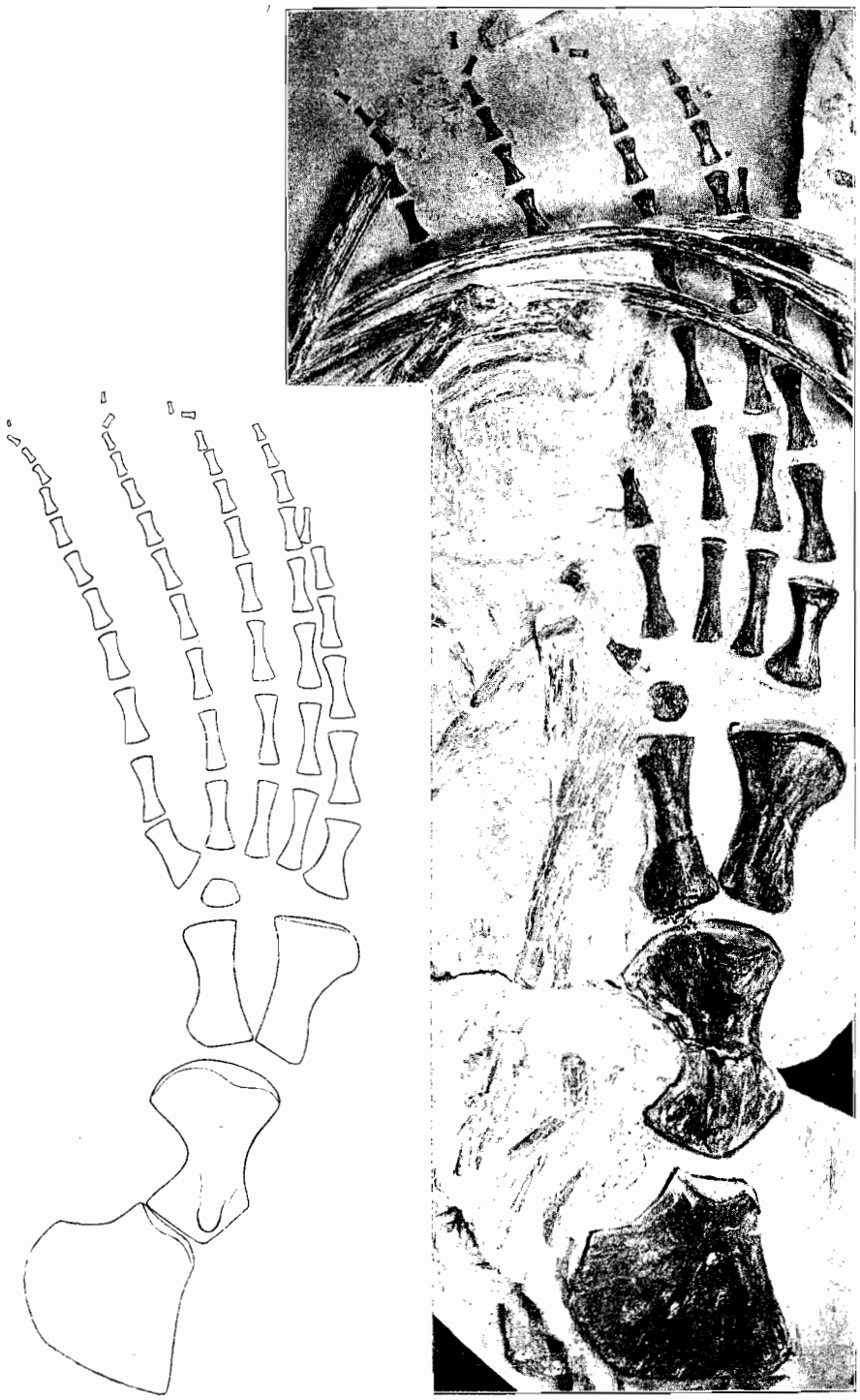
TYLOSAURUS DYSPELOR—s, c, × one-third.



CLIDASTES TORTOR, × one-half.

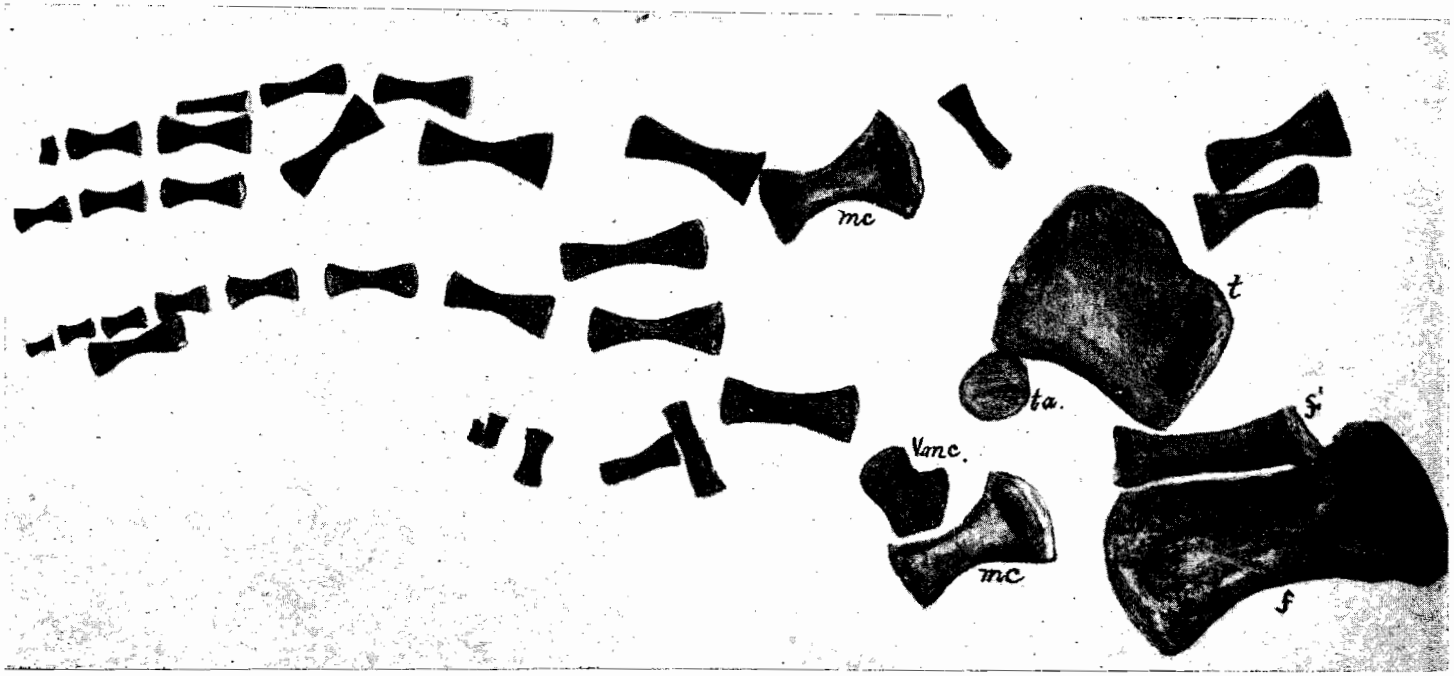


PLATECARPUS SIMUS, × one-half.



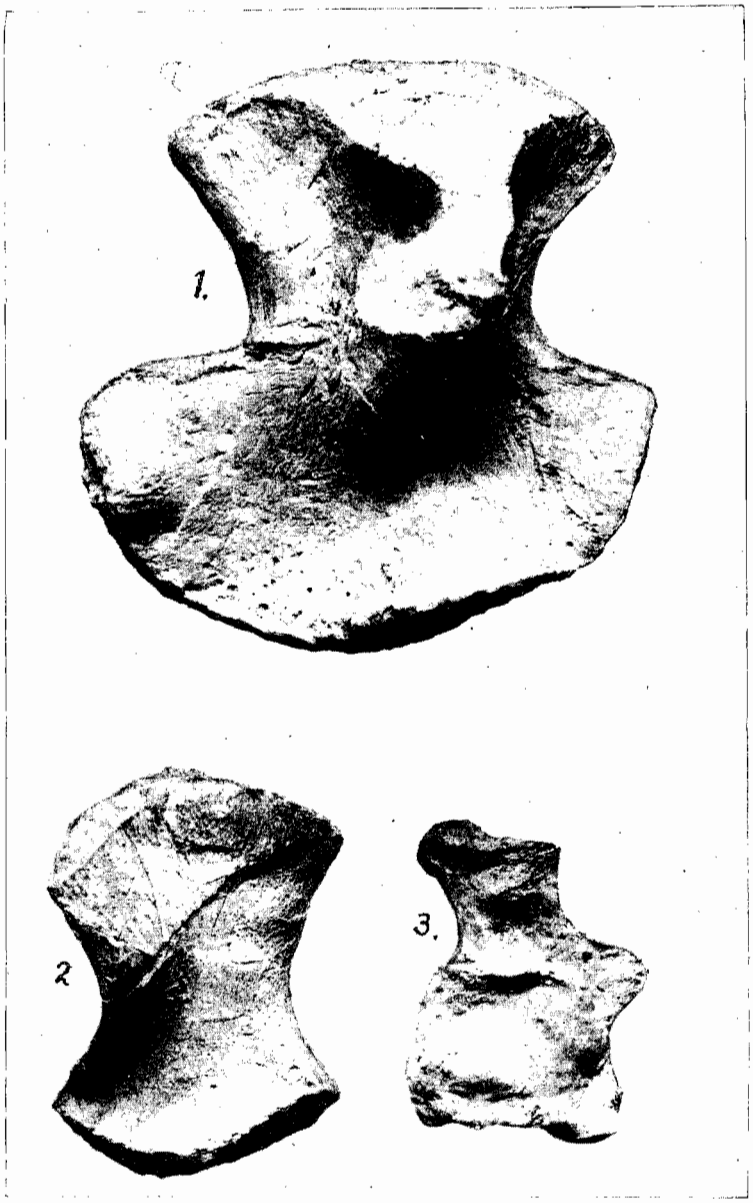
TYLOSAURUS PRORIGER.

TYLOSAURUS PRORIGER.



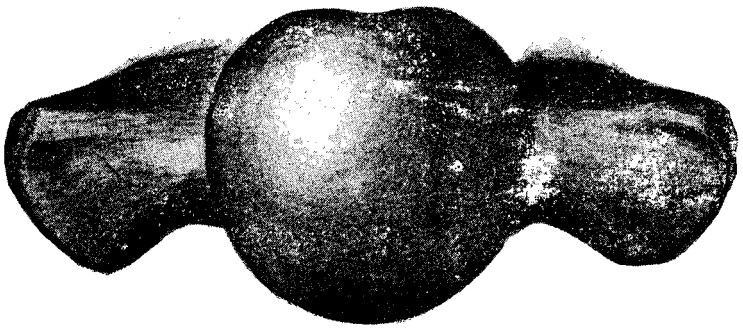
TYLOSAURUS PRORIGER, × one fourth.

PLATECARPUS CORYPHÆUS × three-sevenths.

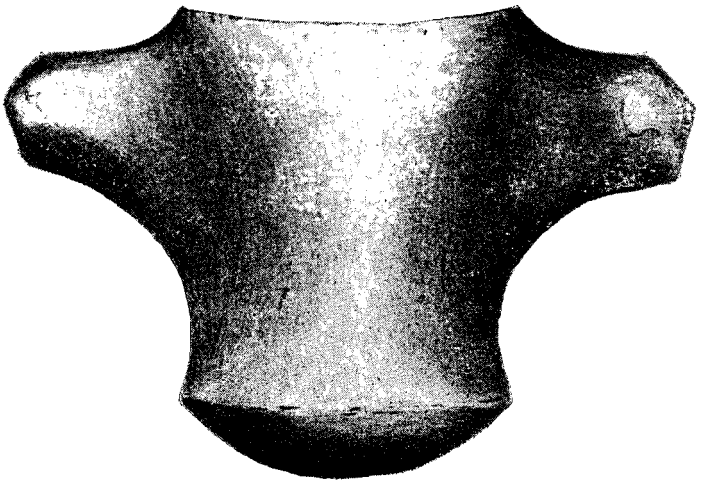


PLATECARPUS CORYPHÆUS, × two-thirds.

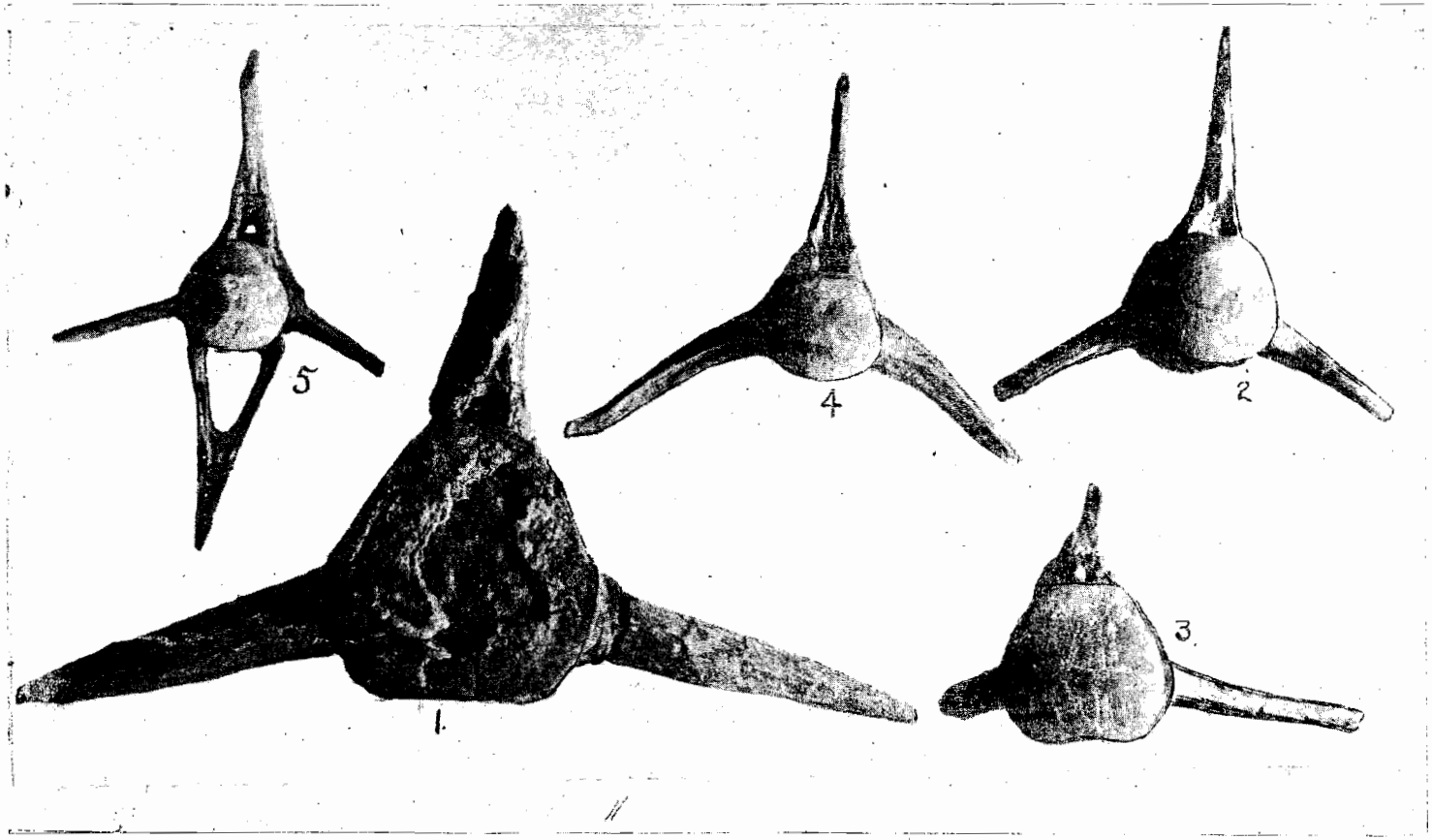
1.



2.

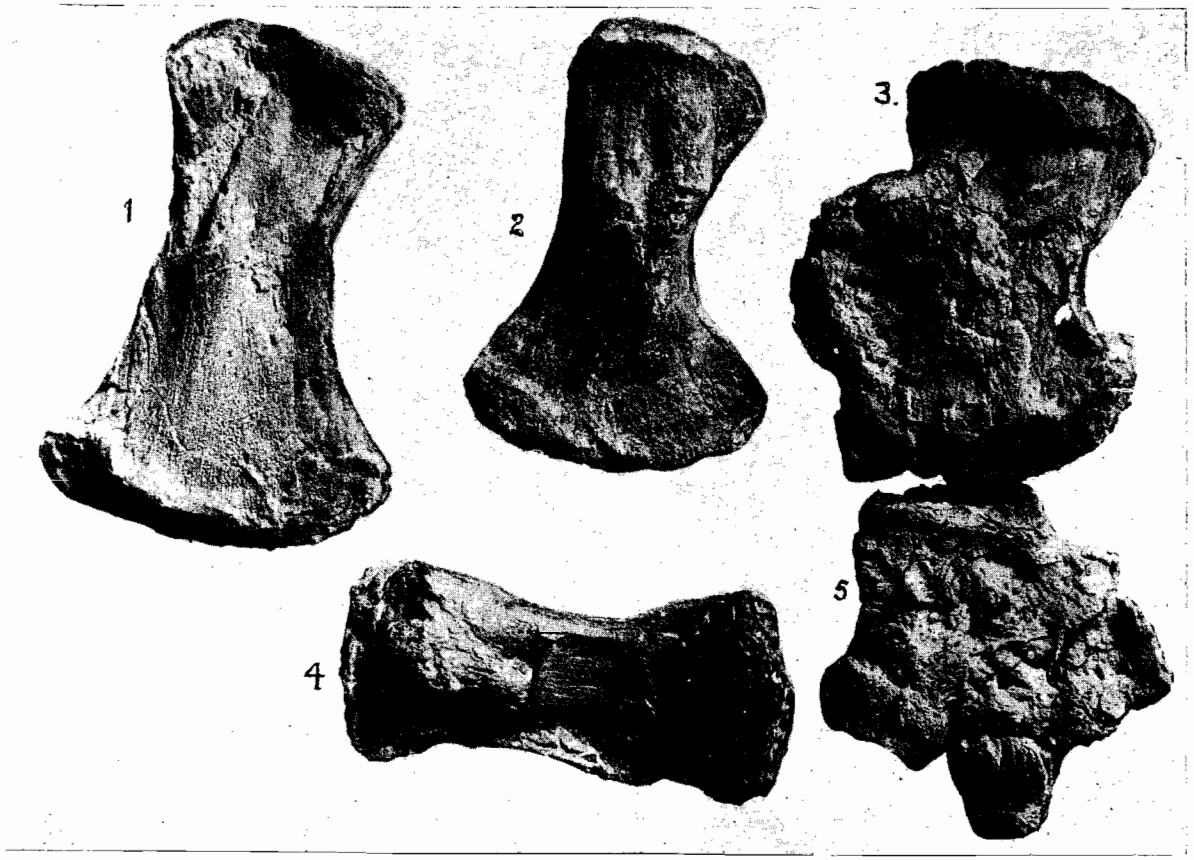


CLIDASTES WESTII, natural size.

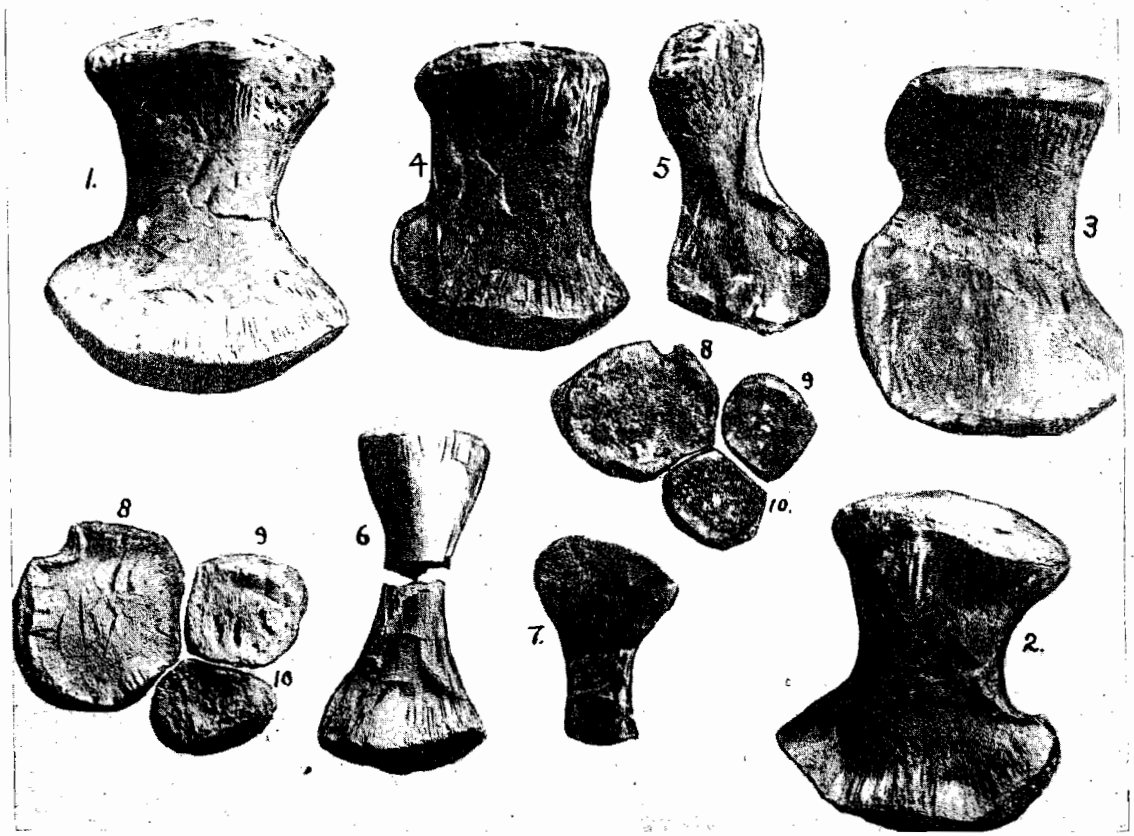


TYLOSAURUS SP.?—1. PLATECARPUS CORYPHÆUS—2, 3. CLIDASTES TORTOR—4, 5.

TYLOSAURUS PRORIGER, × one-half.

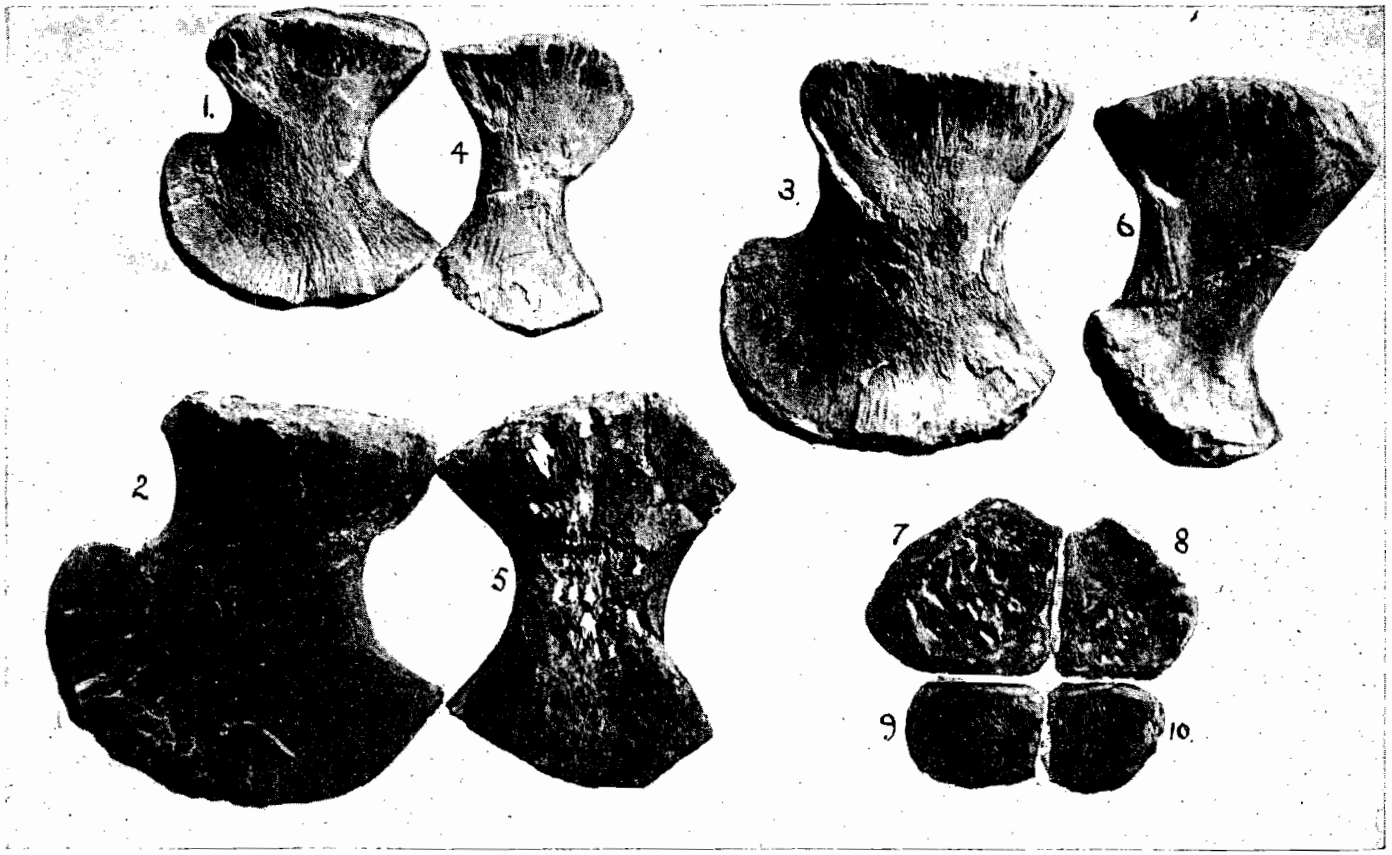


PLATECARPUS CORYPHÆUS, × one-half.

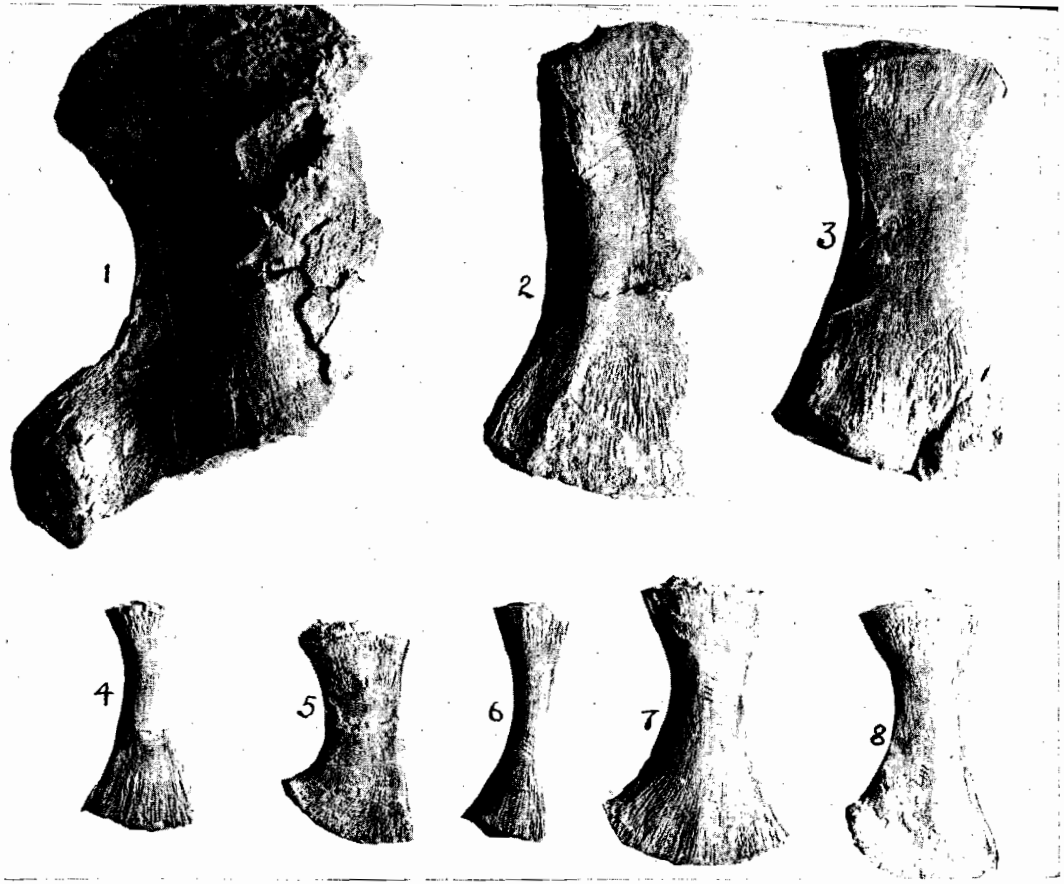


PLATECARPUS SP.?—1, 2. CLIDASTES SP.—3.

PLATECARPUS CORYPHÆUS—5 to 10, × three-fifths.



PLATECARPUS CORYPHÆUS, × three-fifths.



TYLOSAURUS DYSPELOR, × two-fifths.

All × seven-twelfths.

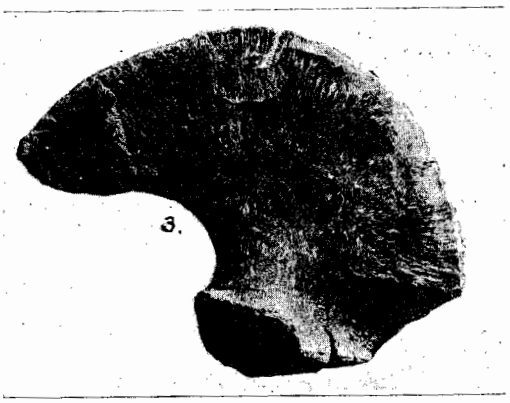
TYLOSAURUS PRORIGER—1, 2.
PLATECARPUS CORYPHÆUS—3.
CLIDASTES WESTII—4.
C. TORTOR—5.
C. VELOX—6, 7.

1.

2.

TYLOSAURUS DYSPELOR—1, 2, × one-third.

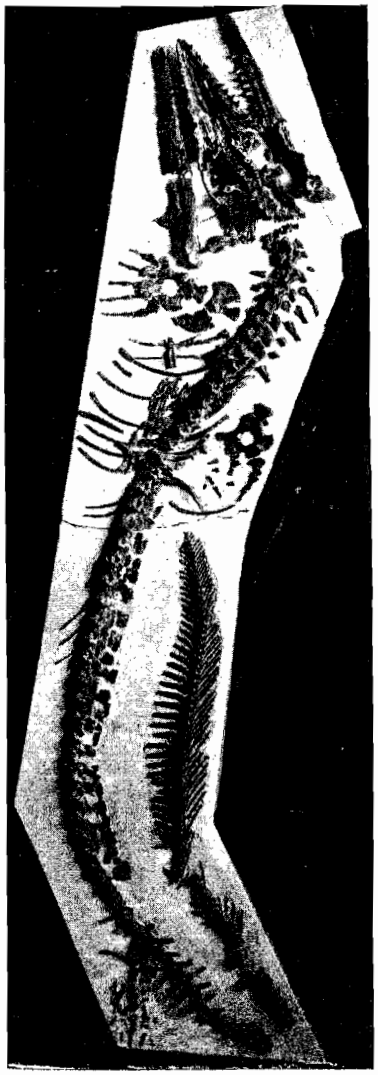
3.



4.

PLATECARPUS CORYPHÆUS—3, × one-half.
CLIDASTES TORTOR—4, × two-fifths.

3.

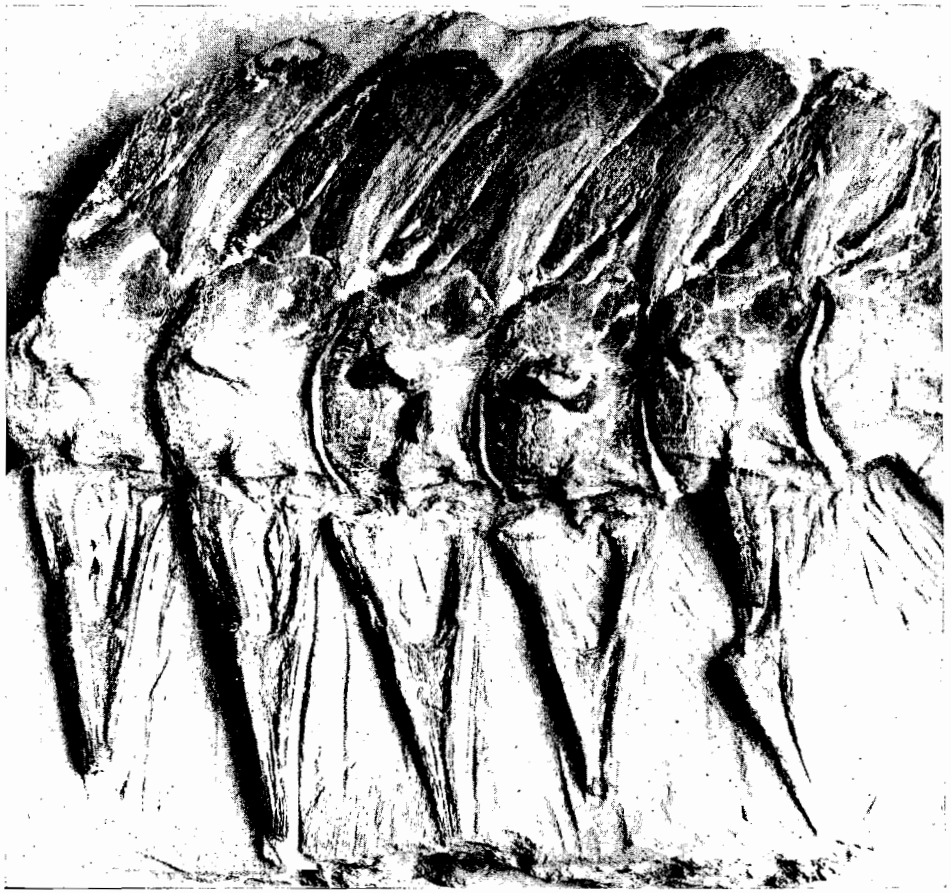


1.

2.

BRACHYSAURUS OVERTONII — 1, 2, × two-fifths.
CLIDASTES VELOX — 3, × one-seventeenth.

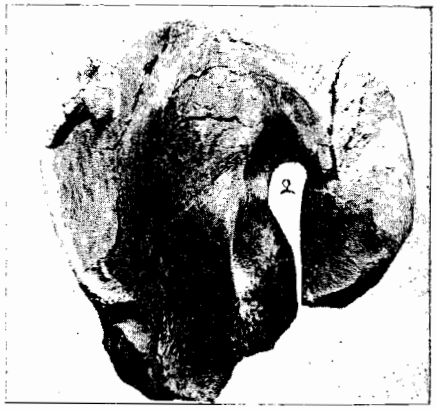
PLATECARPUS CORYPHÆUS, × one-half.



3.

1.

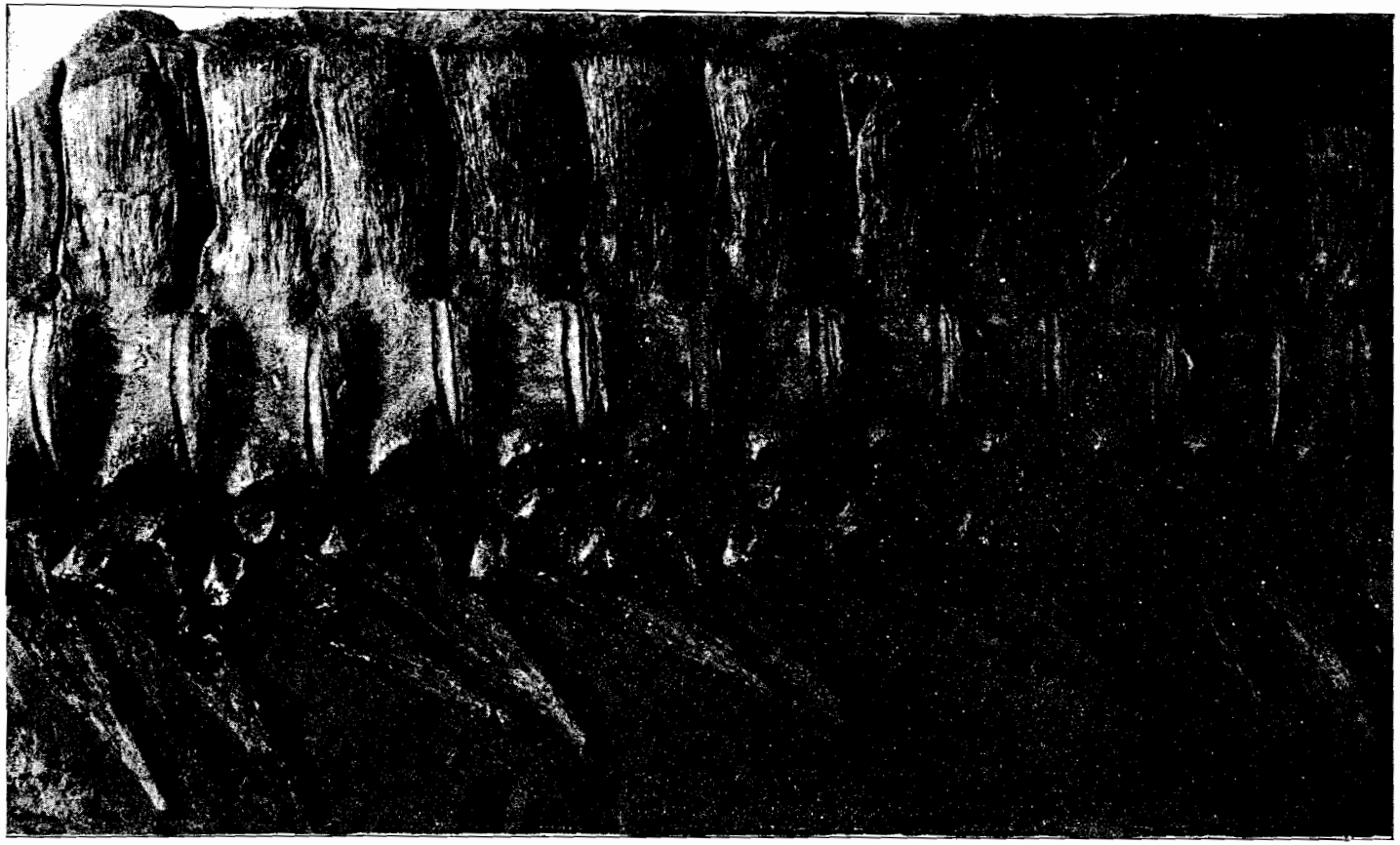
CLIDASTES TORTOR, × two-fifths.



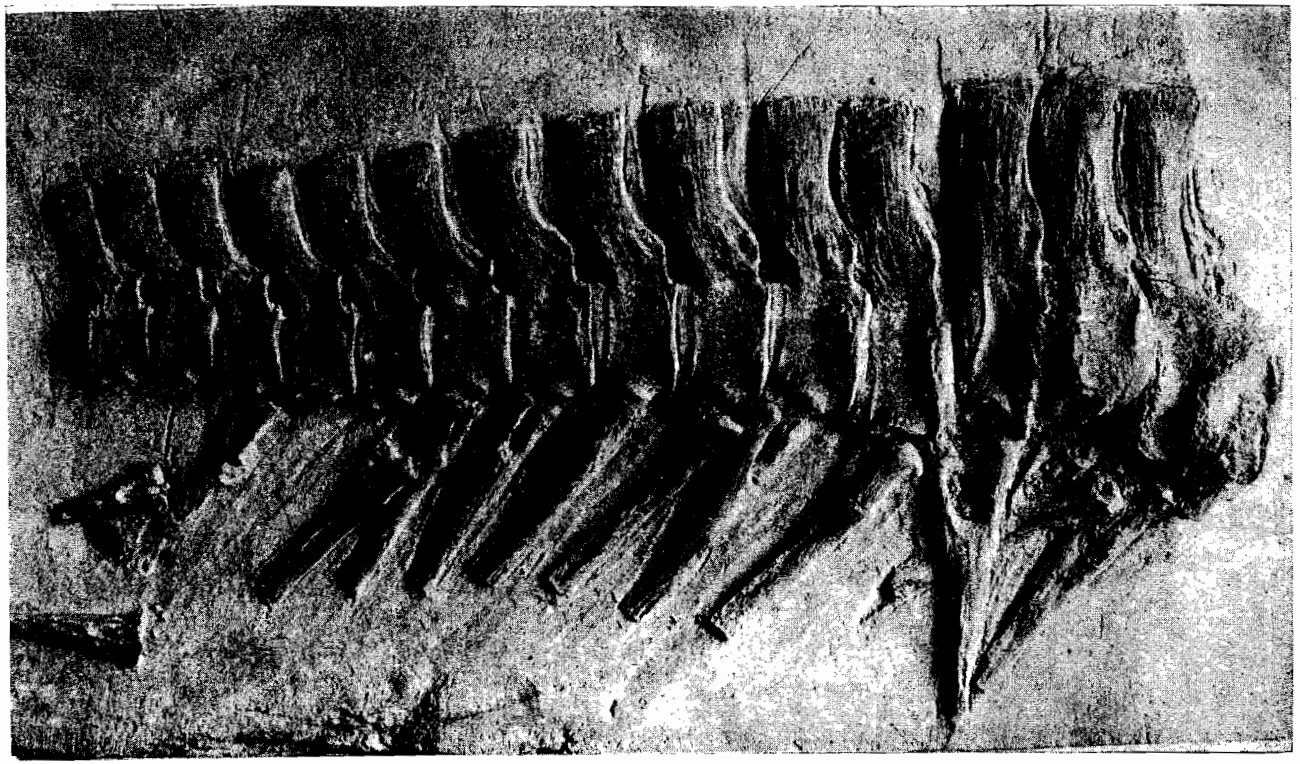
2.

PLATECARPUS CORYPHÆUS—2, 3, × one-half.

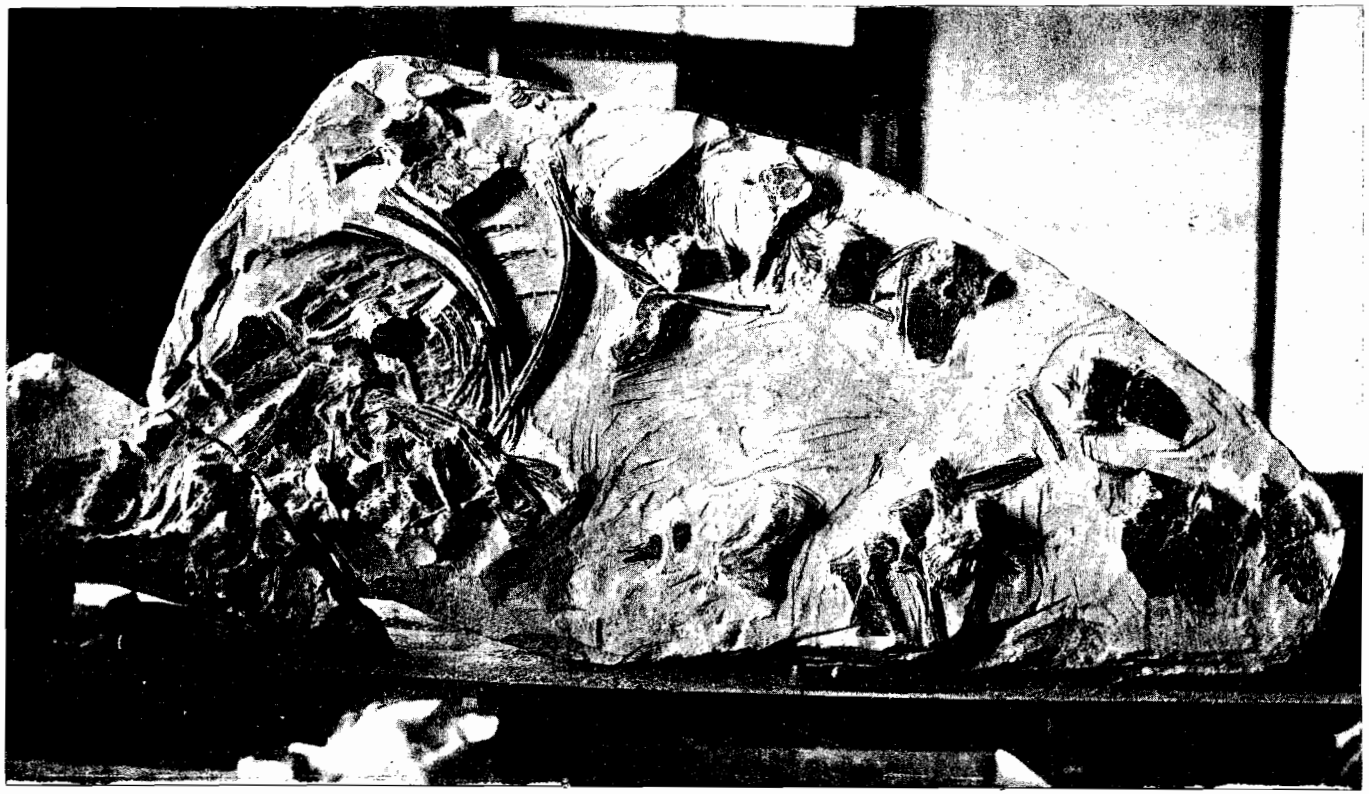
TYLOSAURUS PRORIGER, × one-half.



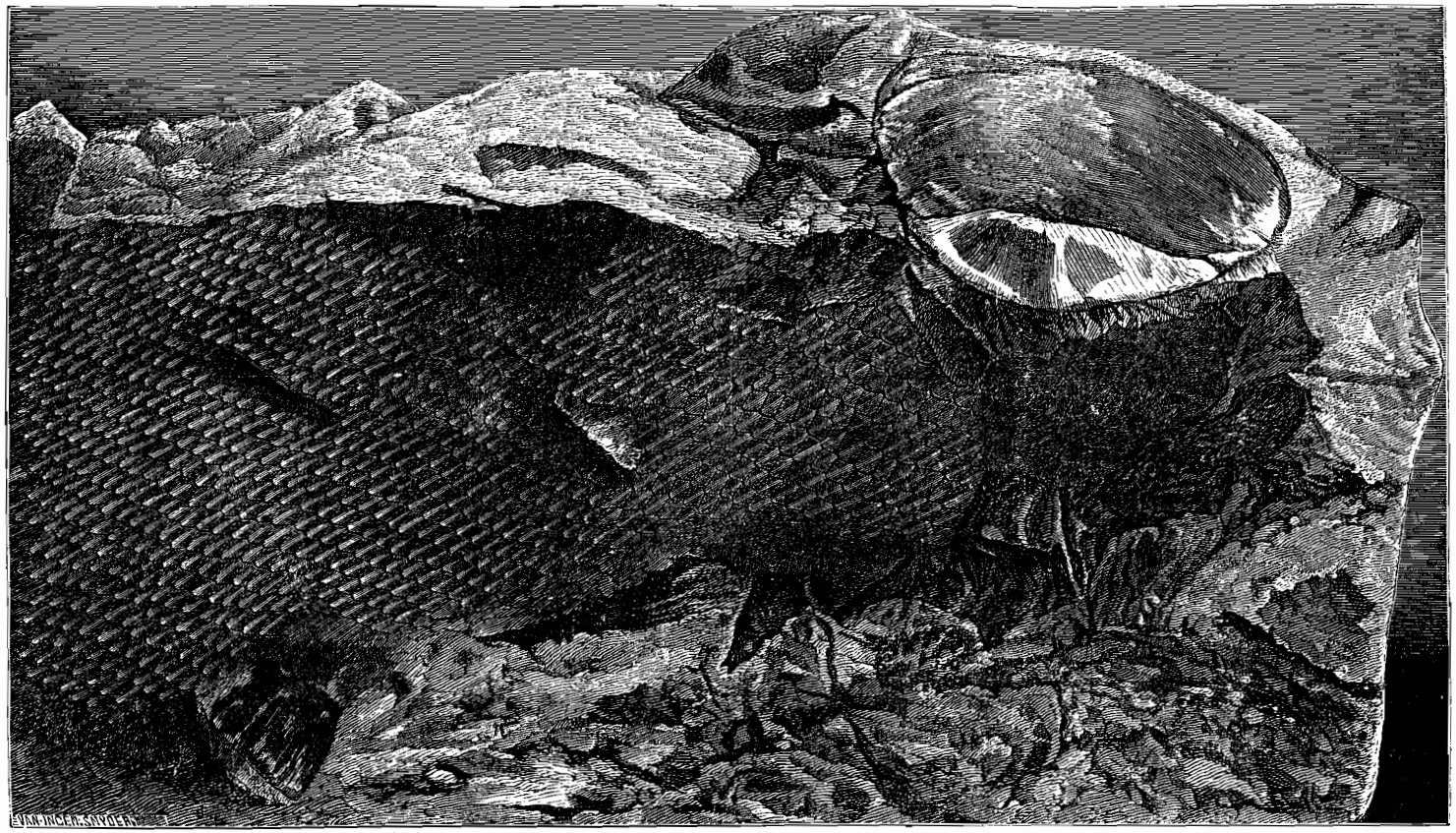
TYLOSAURUS PRORIGER.



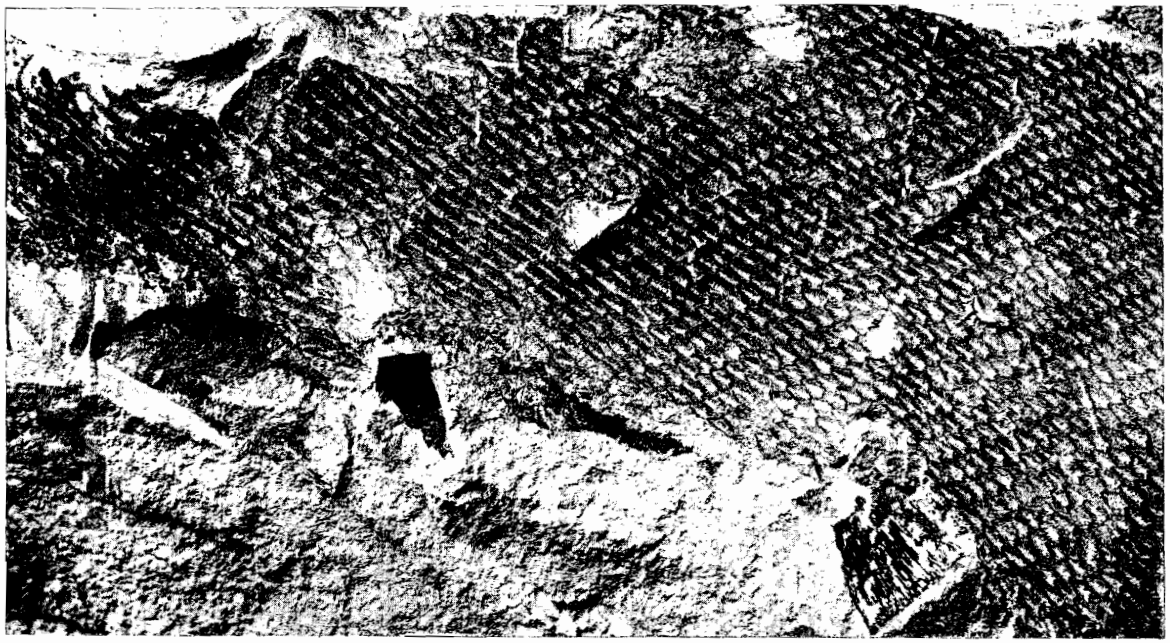
TYLOSAURUS PRORIGER.



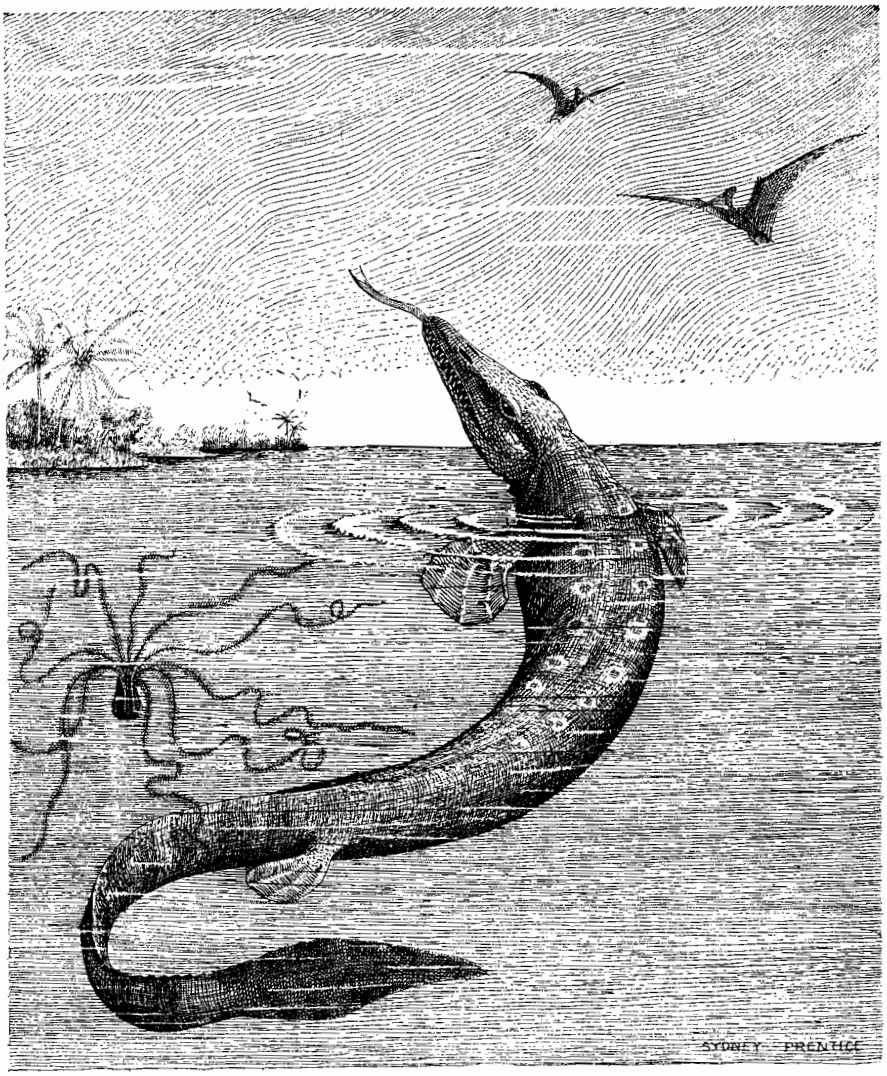
TYLOSAURUS PRORIGER, × one-eighth.



TYLOSAURUS PRORIGER, natural size.

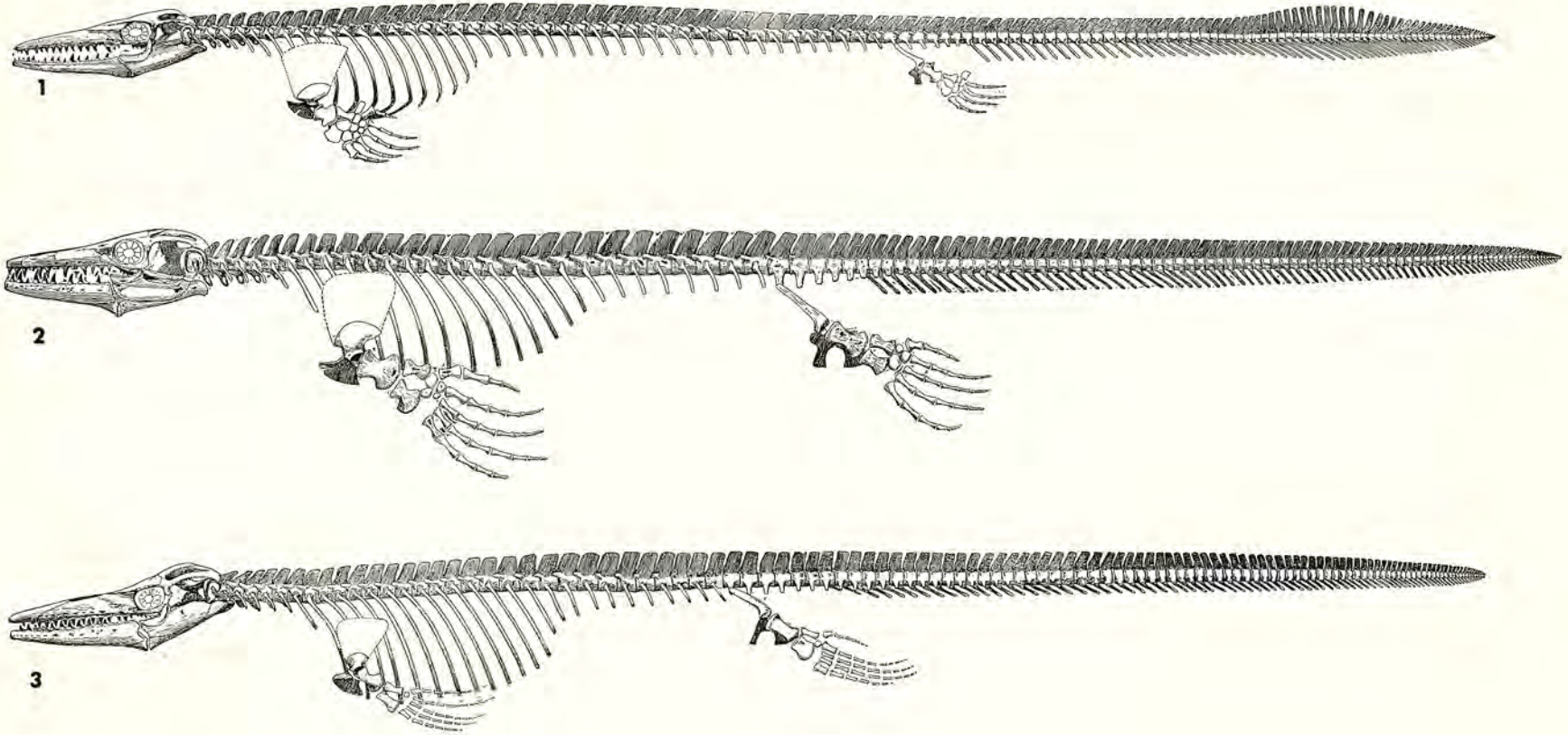


TYLOSAURUS PRORIGER, natural size.



Uintacrinus socialis. *Clidastes velox.* *Ornithostoma ingens.*

LIFE RESTORATION OF KANSAS CRETACEOUS ANIMALS.


1
2
3